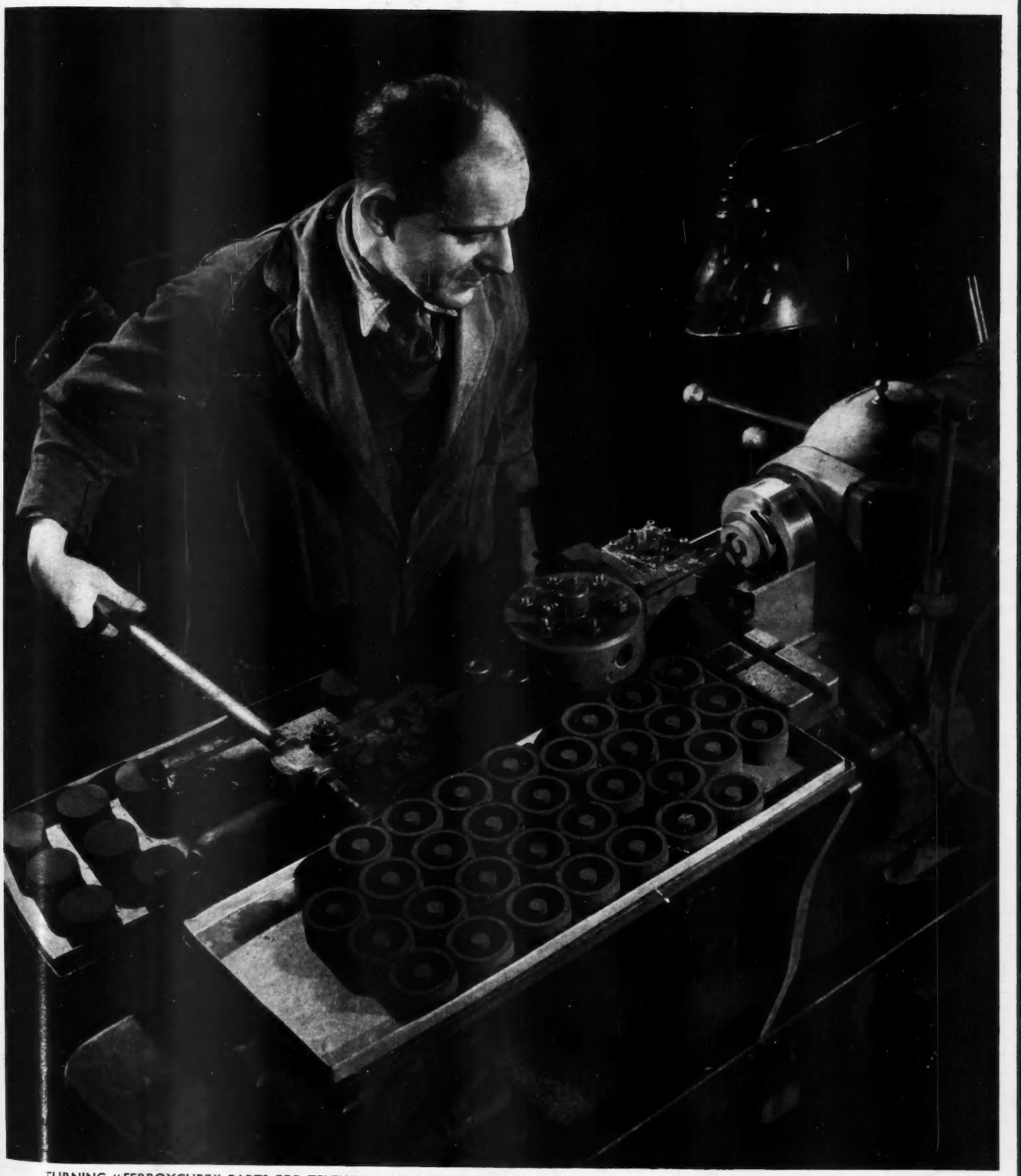
ENGINEERING

An Illustrated Weekly Journal.

EDITED BY CHARLES COOPER AND J. FOSTER PETREE.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2. TELEPHONE: TEMPLE BAR 3663.

Vol. 176—No. 4574. LONDON: FRIDAY, SEPTEMBER 25, 1953. Price 9d.



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PERFORMANCE OF A TWO-STROKE OIL ENGINE FOR AUTOMOBILES.

By PROFESSOR S. J. DAVIES.

THE high price of fuel for carburettor engines has led to increased activity in connection with the possibility of the extension of the use of oil engines to light goods vehicles and to private automobiles. The relative saving in fuel costs to be expected from this change varies from country to country according to the taxation conditions but, given equal prices a gallon of petrol and of fuel oil, a saving of 50 per cent. of the cost of fuel can reasonably be expected. Against this gain, must be placed the rougher running and greater weight and cost of oil engines compared with those of petrol engines, and attention is naturally being given to the possibility of improvements in these respects. When oil engines are considered, the long-standing question arises, four-stroke or two-stroke? The two-stroke oil engine is not subjected to the carry-over loss of fuel, which is the principal drawback of the two-stroke petrol engine fitted with a carburettor, and thus comes definitely into discussion.

A two-cylinder two-stroke oil engine, for example, when compared with a four-cylinder four-stroke oil engine, would have the same curve of turning moment, and broadly the same flywheel conditions, and can be arranged to have the same complete balance of masses of the first order. It would then have the advantage of a somewhat smaller swept volume; with two cylinders instead of four, it would have a simpler and cheaper crankshaft, a smaller number of bearings, an injection pump with two instead of four elements, and two instead of four injection nozzles and pipes; it would be considerably shorter; if exhaust valves were fitted, the number of valves would be less than that of the four-cylinder four-stroke engine, and the driving gear would be much simpler. On the other hand, the cylinder-liner castings would be more complicated, on account of the admission ports, and a scavenging blower would be a necessary expense and complication, and might increase the width of the engine.

The engine which forms the subject of this report provides an interesting example of a modern two-stroke high-speed oil engine. It was designed and developed at the Anstalt für Verbrennungsmotoren Prof. Dr. H. List, consulting engineers, Graz, in collaboration with, and for, the Anstalt für Motorenbau und Konstruktionen, Vaduz, Leichtenstein. Manufacturing rights have been secured by the Turner Manufacturing Company, Limited, Wolverhampton. The chief features of the design will first be discussed; an account will then be given of comprehensive tests of the engine carried out recently by the author on the test bed in the laboratory of the Technische Hochschule, Graz; lastly, the performance and characteristics of the engine will be discussed.

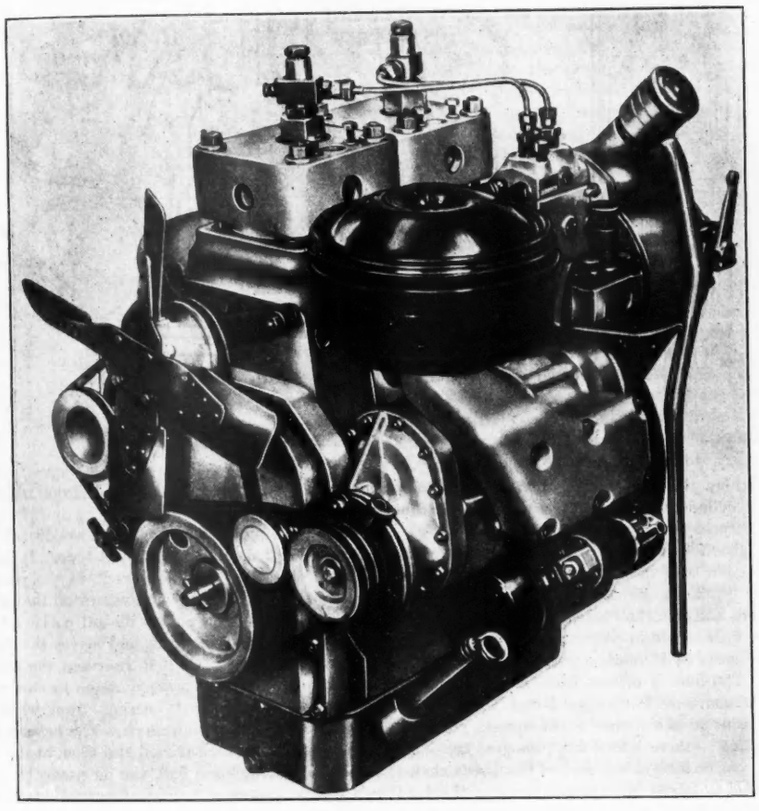


FIG. 1. ENGINE FROM FORWARD END.

Fig. 1 is a view of the engine from the forward end and Figs. 2 and 3, page 386, give longitudinal and transverse sectional elevations, respectively. The engine has two cylinders of 92 mm. (3·62 in.) diameter and a piston stroke of 105 mm. (4·13 in.); this gives a total swept volume of 1·395 litres (85·19 cub. in.). The compression ratio, based on the swept volume, is 19·0 : 1, and the real compression ratio, based on the total volume above the top of the exhaust ports, is 28 : 1, both values having been measured by the author. The present maximum normal output, as limited by the governor, is 35 h.p. at 2,800 r.p.m. The weight of the engine with starter motor, generator, fan, air filter, and exhaust box, but without water and oil, is 376 lb. (171 kg.). It is expected in production models, however, to reduce this to 330 lb. (150 kg.).

The admission of the air and the exhaust of the gases take place through ports in the cylinder wall controlled by the piston, no valves or valve gear being employed. The air from the atmosphere, after passing through the filter seen in Fig. 1, enters directly into the three-lobed Root's blower placed below the filter. It is delivered from the blower to a reservoir, from which it enters the cylinder through the admission ports. The ports are arranged symmetrically about a transverse plane; there are four admission ports on each side and these may be seen in Fig. 2; there are three exhaust ports. This arrangement provides for loop scavenging in the cylinder, the streams of entering air converging as they pass upwards towards the cylinder head, and then, after making their loop motion, pass outwards horizontally through the exhaust ports.

The advantages of loop scavenging are, firstly, that the elimination of the valves and their gear leads generally to simpler, cheaper, and more reliable manufacture; secondly, since valves and their drives are heavily stressed at high speeds of revolution, their elimination brings about less risk of breakdown and easier maintenance; thirdly, the cylinder heads are simpler in design, a matter of special importance with small cylinder sizes, their manufacture is cheaper, and the thermal stresses to which they are subjected are less complicated. A possible drawback with single-piston engines, which need not arise with opposed-piston engines and with engines having exhaust valves, is the symmetrical timing of the admission and exhaust ports. A second drawback is that the rates of opening and closing of the ports are determined by the movement of the piston and, apart from the shape of the ports, their operation cannot arbitrarily be changed by the designer. Both drawbacks, however, can be largely overcome by correct design of the charging and exhaust systems.

The form of the combustion chamber can be seen in Figs. 2 and 3. Although the classification of combustion chambers is a debatable subject, the author adheres to a classification given earlier,* in which the present case falls into class 1, namely, that in which the fuel is injected into the air in which combustion is to take place, but falls further into sub-division (*c*), in which this air is contained in a separate chamber. The chamber is symmetrical about its axis, which coincides with that of the fuel nozzle; the other fitting visible in Fig. 3 is the heating spiral, which is necessary for starting the engine at low atmospheric temperatures. The top of the piston is flat. Both the piston and the cylinder head are made of aluminium alloys; the chamber is of heat-resisting steel in two parts and, after machining the parts and welding them together, is fixed in the cylinder head in the casting process of the latter. The advantages of this form of combustion chamber are that it renders possible a high brake mean-effective pressure, and gives a clear exhaust with a relatively small excess of air; that a pintle nozzle may be used; and that the thermal loading on the piston is relatively low, since the gases when at their highest temperatures do not come into contact with the piston.

It will be seen that the engine body comes to the tops of the cylinders, and the faces of the casting are in projecting planes to facilitate machining. No pipes for the lubricating oil are used, all oil passages being in the engine body itself. Considerable thought has been given to the arrangement of the auxiliaries: the scavenging blower, the radiator fan, and the electrical generator are driven by V-belts at the front of the engine; and the impeller of the water pump is carried on the shaft of the generator, so that a special drive for the pump is unnecessary. The arrangement of the water pump, the oil cooler and the oil filter permits a simple correlation of these elements. The fuel pump is carried high up on the engine, so that the fuel

* *Proc. Inst. Mech. E.*, page 685 (1932).

TWO-STROKE OIL ENGINE FOR AUTOMOBILES.

Fig. 2.

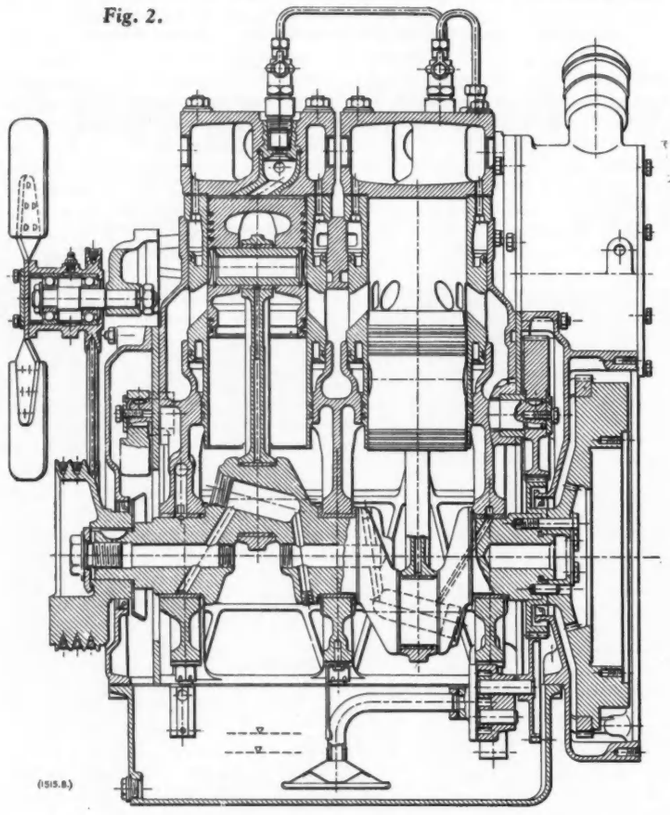
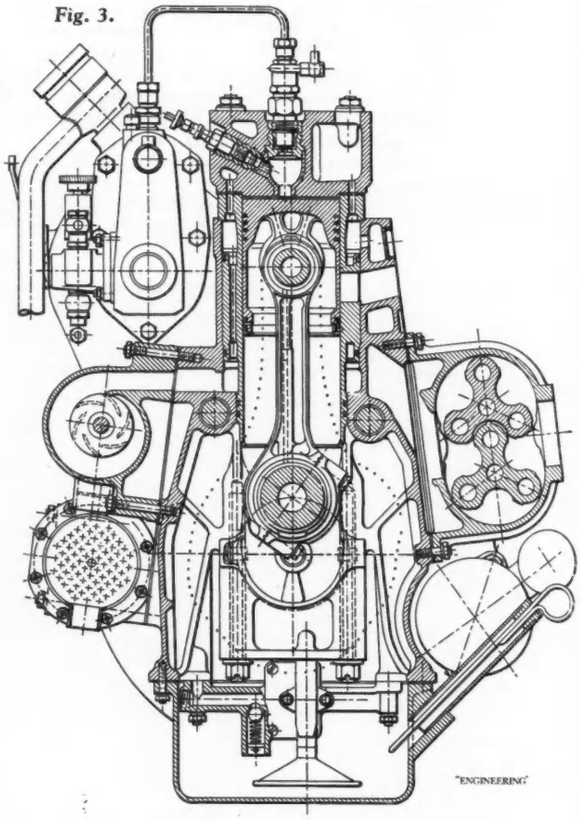


Fig. 3.



pipes are very short and thus give a low injection lag, which is an important matter in high-speed engines. The fuel pump and the pump for the lubricating oil are driven by gear wheels carried at the flywheel end of the engine. An interesting feature is that the sealing of the crankcase at the flywheel end is arranged within the driving gear wheel on the crankshaft, so that the length of the engine is correspondingly reduced.

The question of obtaining the same balance of masses of the first order with a two-cylinder two-stroke engine as with a four-cylinder four-stroke engine has already been mentioned. The method of obtaining this balance in the present case is noteworthy. The drive to the fuel pump is taken from the driving wheel on the crankshaft, through an intermediate gearwheel, to the gearwheel on the pump shaft; this last wheel is, of course, equal in pitch diameter to that on the crankshaft, since the speed of revolution of the pump is the same as that of the crankshaft. A secondary wheel, of the same dimensions as the intermediate wheel and placed at very nearly the same height relatively to the crankshaft, is arranged to be driven by the intermediate wheel. The intermediate wheel and the secondary wheel are each fixed to longitudinal shafts which are shown in section in Fig. 3 and extend over the length of the engine. The axes of the longitudinal shafts are at the same distance on each side of the central transverse plane of the engine. Each of the wheels is provided with an out-of-balance weight. These weights are so arranged that the horizontal components of the out-of-balance forces set up in each pair balance one another; similar out-of-balance weights are fixed to the forward ends of the longitudinal shafts. The vertical components of all the weights are so arranged that their resultants produce a couple in the central transverse plane which, at any instant, is equal to and opposite in sense to the couple produced by the reciprocating masses in the two lines of cylinders. The complete system is thus always in primary balance.

The piston has four pressure rings above the gudgeon pin and two scraper rings below. The cylinder heads are secured to the engine body by four studs and nuts, and are easily removable. The cylinder liner is held in position by the heads and, by suitable gaskets, is made pressure tight with the heads. The liner is of cast iron. Its construction can be understood from Figs. 2 and 3. An interesting point in the design is the special provision for cooling: there are four passages providing cooling, one on each side of each of the three exhaust ports, and a group of passages through the land between the two groups of admission ports. These passages are in line with the corresponding passages through which the cooling water passes upwards to the cylinder heads. When the heads are removed, it is easily possible to remove all deposits and scale from the walls of the passages; a special tool is provided for this purpose. Since the cylinder heads are easily taken off, it is a simple matter of maintenance to keep these passages in such a state that cooling is effectively carried out.

The circuit through which the cooling water passes is as follows: leaving the radiator, the water first enters the oil cooler, to be seen below the water pump in Fig. 3. It then enters the pump, and is delivered to the engine body, where it takes heat away from the outer side of the cylinder liner and from the exhaust passage, the speed of the water here being low. The main stream then passes vertically upwards through the passages, already referred to, in the cylinder liner; a small part of the water passes upwards around the exhaust passage. All the water enters the annular space around the upper part of the cylinder liner, and then flows upwards through a large number of small passages distributed around the top of the liner and enters the cylinder head, from which it returns to the radiator.

The oil pump, which can be seen low down on the right in Fig. 2, is of the gearwheel type. It draws oil from the sump and delivers it to the passage drilled in the engine body and shown on the left in Fig. 3. The oil then enters the oil cooler at the flywheel end, flows forwards, and leaves the cooler through a laminar filter; it re-enters the engine body through a drilled passage at the forward end, which leads to the first bearing, from which it flows into the hollow crankshaft. The big-end and main bearings receive their oil and then, at the last bearing at the flywheel end, the oil passes through two inclined passages to the after bearings of the longitudinal shafts. These shafts are enclosed in cylindrical passages which are filled with oil, and in this way their forward bearings receive their oil. From the shaft passage on the blower side, two drilled holes lead the oil to the bearings of the blower, from which it is led back to the engine body through two further drilled holes. The cylinder liners and the gudgeon pins are lubricated by oil mist. Fresh oil is supplied to the engine through the filler, seen in the top right-hand corner in Fig. 1. This also acts as a breather for the engine body.

The governor is fixed to the gearwheel of the fuel pump and is enclosed by the after casing. It has a spring for slow running and a spring to limit the top speed of the engine, both carried on the axis. When the engine is slow running without load, at about 600 r.p.m., the levers of the governor act only on the slow-running spring. At the maximum speed of 2,800 r.p.m., the spring limiting the speed is compressed by the action of the rotating weights, so moving the rod connected to the spring. This rod, through a lever, moves the control rod of the pump in the direction to cut-off the fuel supply. Through the main control lever, working through

an eccentric, it is possible to deliver any desired quantity of fuel, from zero to the maximum.

In the basic tests, the engine was run at a series of constant speeds, namely, 1,200, 1,600, 2,000, 2,400, and 2,800 r.p.m., and, in each series, the loads were varied from light to full. The principal data from these tests are tabulated in Table I, and are derived from the observations of the brake torque, the revolutions per minute, and the fuel consumption. The power developed by the engine was measured by means of an electrical dynamometer of the torque-reaction type; this was afterwards uncoupled from the engine, its zero balance and its dimensions were checked and found to be without measurable error. In the table the brake torques have been converted into the equivalent values of B.M.E.P.

TABLE I.

Test No.	R.P.M.	B.M.E.P., lb. per sq. in.	B.H.P.	Fuel, lb. per hour.	Fuel, lb. per B.h.p., per hour.
A 1	1,182	1·1	—	1·83	—
A 2	1,192	10·9	2·82	2·68	0·950
A 3	1,195	23·8	6·1	3·66	0·600
A 4	1,191	35·4	9·1	4·61	0·507
A 5	1,190	44·5	11·4	5·35	0·469
A 6	1,192	47·8	12·3	5·71	0·464
A 7	1,178	51·8	13·2	6·08	0·461
A 8	1,190	54·0	13·9	6·45	0·464
A 9	1,197	57·0	14·7	6·88	0·468
A 10	1,190	60·0	15·4	7·36	0·478
B 1	1,578	9·6	3·3	3·43	1·039
B 2	1,600	18·0	6·2	4·31	0·695
B 3	1,628	28·9	10·1	5·58	0·552
B 4	1,615	46·4	15·7	7·30	0·465
B 5	1,590	50·5	17·3	7·89	0·456
B 6	1,635	58·3	20·5	9·28	0·453
B 7	1,630	60·9	21·4	9·70	0·453
B 8	1,602	65·6	22·7	10·76	0·474
B 9	1,643	66·0	23·4	10·96	0·468
C 1	1,990	16·6	7·2	5·45	0·757
C 2	1,978	26·6	11·4	6·64	0·582
C 3	1,975	35·7	15·2	7·91	0·520
C 4	1,995	47·8	20·5	9·76	0·476
C 5	1,990	52·1	22·4	10·49	0·468
C 6	1,985	54·9	23·6	10·91	0·462
C 7	1,970	57·6	24·4	11·42	0·468
C 8	1,955	60·6	25·6	11·77	0·460
C 9	1,975	63·3	27·0	12·39	0·459
C 11	1,940	65·7	27·5	12·85	0·467
C 12	1,976	71·0	30·2	14·62	0·484
D 1	2,355	1·4	—	4·82	—
D 2	2,345	17·8	9·0	7·14	0·793
D 3	2,355	27·2	13·8	8·53	0·618
D 4	2,360	44·1	22·5	11·51	0·512
D 5	2,325	48·9	24·5	12·37	0·505
D 6	2,340	52·2	26·4	13·07	0·495
D 7	2,340	54·9	27·7	13·67	0·494
D 8	2,365	61·9	31·7	15·54	0·490
D 9	2,360	64·3	32·7	16·02	0·490
D 10	2,360	65·4	33·4	16·45	0·493
D 11	2,360	69·1	35·2	18·52	0·526
E 1	2,750	1·4	—	6·35	—
E 2	2,805	17·1	10·3	9·15	0·884
E 3	2,780	27·6	16·6	11·13	0·671
E 4	2,770	43·1	25·8	14·46	0·560
E 5	2,745	45·4	26·9	14·95	0·556
E 6	2,750	48·1	28·6	15·78	0·552
E 7	2,780	52·9	31·8	17·26	0·543
E 8	2,775	55·3	33·1	17·81	0·537
E 9	2,790	60·0	36·2	19·71	0·544
E 10	2,795	61·4	37·1	20·17	0·544
E 11	2,795	63·9	38·5	22·88	0·594

While a tachometer afforded a continuous check of the constancy of the speed of revolution, the counting of the revolutions and the fuel consumption were simultaneously observed. The time to consume a measured volume of fuel was observed by means of a stop-watch; the counter, which received through a contact on the dynamometer shaft an electrical impulse once every revolution, was switched on at the instant when the consumption of the measured volume of fuel commenced, and switched off again at the instant this volume was consumed. The quantity of fuel to fill the measured volume was weighed and from the times, as observed by the stop-watch during the tests, the fuel consumption in pounds per hour and the revolutions per minute of the engine were calculated. The small quantities of leakage oil were measured, and, for the calculations, subtracted from the measured volume. The rate of flow of the circulating water was adjusted to give in all tests an outlet temperature of 176 deg. F. (80 deg. C.).

During the tests the barometer stood at 29·1 in. (737 mm.) of mercury and the room temperature was never below 64 deg. F. (18 deg. C.). The gas oil used during the tests was submitted for investigation to Professor Dr. G. Jantsch, of the Department of Chemistry, the Technische Hochschule, Graz, who reported as follows: "The specific gravity was 0·844 at 68 deg. F. (20 deg. C.). The lower calorific value was 17,900 B.Th.U. per lb. (9930 kcal. per kg.) and the higher calorific value was 19,520 B.Th.U. per lb. (10,860 kcal. per kg.)." The lubricating oil used was Mobiloil A.

(To be continued.)

LITERATURE.

The Elements of Astronomy for Surveyors.

By R. W. CHAPMAN, M.A., B.C.E. Fifth edition, revised and enlarged, by J. B. MACKIE, M.Sc., B.E. Charles Griffin and Company, Limited, 42, Drury-lane, London, W.C.2. [Price 26*s.* net.]

THE number of text-books available for the practical plane surveyor is legion, and the same applies to those dealing with astronomical matters under the guise of navigation; but there is a scarcity of books which couple the practical essentials of observational astronomy with geodetic surveying technique, although these two branches are closely allied. In countries where local maps and charts are scarce, and probably inaccurate, the surveyor must ascertain his own local time, latitude, longitude and meridian, and to do this a working knowledge of the elements of astronomy is essential. This useful book by the late Sir Robert Chapman, formerly of the University of Adelaide, which appeared first in 1918 and in its fourth edition in 1933, has now been thoroughly revised by Mr. J. B. Mackie and provides the surveyor of undeveloped lands with the basic information needed to overcome a lack of published data on the kinds indicated.

The subjects covered in the 13 chapters include the location of objects on the celestial sphere; astronomical and instrumental corrections to observations of altitude and azimuth; the determination of true meridian, latitude, time and longitude; the simultaneous determination of latitude and longitude from position lines; and the convergence of meridians. The points of difference between this edition and the fourth appear mainly in the chapters on time and longitude, and in the inclusion of the chapter on position lines; this chapter is new, though the methods described are well established; but it is rather surprising to find that no mention is made of the recent adoption, in certain nautical almanacs, of the tabulation of a star's position by its Greenwich hour angle (G.H.A.) rather than its right ascension. A chapter devoted to an explanation of this system, with instructions on the use of the new tables, would have been a useful addition. Mr. Mackie states, in his preface, that the *Star Almanac for Land Surveyors*, recently produced by the Admiralty, provides data sufficiently accurate for all ordinary survey work; but he points out that, as the positions of stars are no longer given in the *Nautical Almanac*, precise work will require the use of another publication, namely, *Apparent Places of the Fundamental Stars*, obtainable from H.M. Stationery Office.

Technology of Engineering Materials.

By B. RICHARD HILTON. Butterworth's Scientific Publications, Bell-yard, Temple Bar, London, W.C.2. [Price 36*s.* net.]

THE word "technology" has so broad a field of meaning that the scope of this book is perhaps not defined clearly enough by its title. What Mr. Hilton has done—and, it may be said at once, has done exceedingly well—is to describe the processes which engineering metals and alloys undergo prior to their appearance as castings or forgings ready for machining or fabrication. Engineering students often have no more than a hazy idea of what those processes involve, while mature engineers can find all too little time to keep abreast of developments in industrial metallurgy; and, though Mr. Hilton exaggerates a little when he implies that a complete understanding of every aspect of materials, from the crude ore to the finished product, is of vital importance to the engineer, it will not be disputed that a sound background of such knowledge can be valuable as well as interesting. Nowadays, moreover, the subject appears or predominates in the syllabuses of many technical courses and qualifying examinations, creating the need for a concise yet comprehensive text-book embodying just enough detail to be accurate without being overburdened with theoretical metallurgy.

Mr. Hilton meets this need admirably in his eminently practical and profusely illustrated book, in which the half-tone reproductions, diagrams, and tabulated data are selected to give the maximum visual aid and the fullest appreciation of the text. In two main sections he deals separately with ferrous and non-ferrous metals and alloys, in each case saying something of the mining of the ores and the first stages of smelting and refining into raw metallic material. The secondary stages of metallurgical production are described at greater length, and the subsequent mechanical and thermal treatments are discussed in sufficient detail to permit critical comparisons among the various methods employed, the reasons underlying different processes, and the results achieved with them. The six chapters comprising the bulk of the information about metals and alloys are preceded by an excellent account of patternmaking, moulding and foundry practice, and followed by a useful glossary of words, phrases and proprietary terms covering the field of metal processing. A point of some importance to British readers is that all such technical terms are those commonly used in this country, and that the author's descriptions and illustrations of equipment and processes are based almost exclusively on the plant and practices of British firms. An appendix presenting a table of physical properties for commonly-used engineering metals supplements the data on mechanical strength and alloy composition given elsewhere in the book and, together with the glossary and a carefully compiled index, should encourage reference to a work of undoubted value.

Elements of Propeller and Helicopter Aerodynamics.

By PROFESSOR D. O. DOMMASCH. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 35*s.* net.]

THIS volume, one of the Pitman Aeronautical Engineering Series, consists of a series of lectures given by the author to test pilots of the United States Naval Air Test Centre, and presents the elements of the theory of the propeller and of the helicopter rotor in one course. This is logical enough, though the working states of a helicopter rotor differ considerably from those of the tractor propeller. The early chapters are devoted to a review, inevitably sketchy, of the principles of aerodynamics, and, in particular, of the propeller theories of Glauert, Goldstein, Theodorsen and Lock. In the later chapters, equations are derived for rotor thrust and torque, from which the helicopter performance characteristics can be calculated. In the final chapter, on the control and stability of the helicopter, no attempt has been made to treat the subject mathematically, but a good description is given of the physical nature of the problem. The author retains the customary propeller notation, whereas most helicopter workers have found it preferable to adopt a notation more convenient to this new and important subject; nevertheless, the student who is familiar with propeller theory will find this book a useful introduction to the helicopter, and should be able to work the simple performance problems posed at the end of each chapter. Much more study will be required, however, before the significance is realised of the many assumptions made in these preliminary lectures.

DEVELOPMENTS IN FLUORESCENT TUBES.

GENERAL ELECTRIC CO., LTD., LONDON.

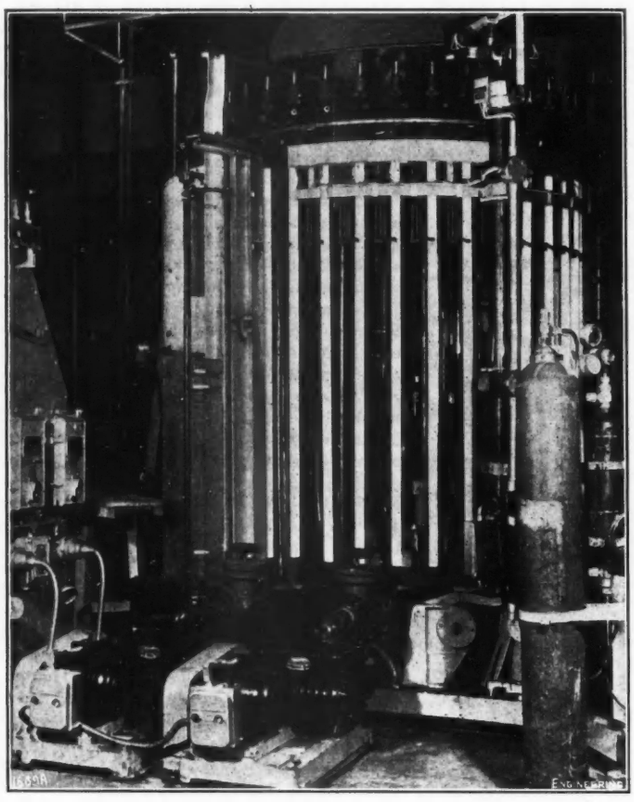


FIG. 1. AUTOMATIC VACUUM PUMPING MACHINE.

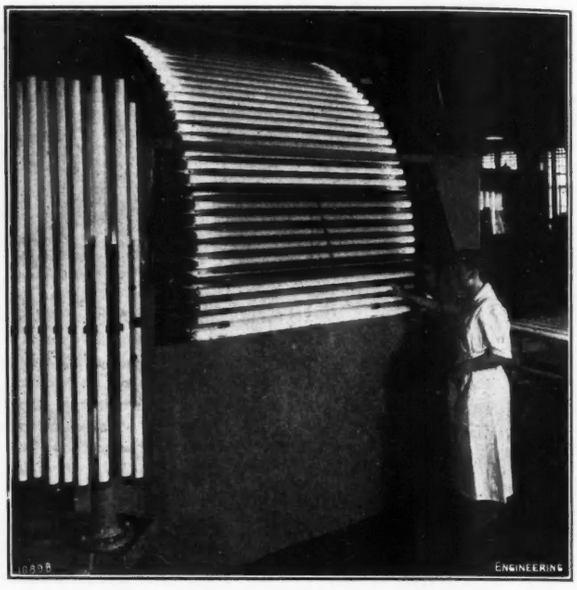


FIG. 2. AUTOMATIC STABILISING MACHINE.

RECENT DEVELOPMENTS IN FLUORESCENT TUBES.

THE luminous effects, which occur when an electric discharge is passed through a gas or vapour, have been known for many years; and were, in fact, demonstrated by Hawksbee before the Royal Society as long ago as 1710. Little or no practical use was, however, made of them for nearly 200 years when Moore, and subsequently Claude, invented tubes containing carbon dioxide, nitrogen, neon and helium, sometimes with and sometimes without mercury, in which white and coloured lights were produced. These lamps soon found considerable application for decorative and other purposes, in spite of their low luminous efficiency, a disadvantage which was overcome in 1932 when use was first made of the property that certain substances glow (or become fluorescent) when exposed to ultra-violet radiation. These substances, which have been given the generic names of phosphors, include zinc-beryllium silicate, magnesium tungstate, cadmium chlorophosphate and cadmium borate. Zinc-beryllium silicate becomes highly fluorescent with the addition of manganese and can be prepared to give a variety of yellowish-white and reddish colours. Magnesium tungstate fluoresces with a pale blue colour, cadmium chlorophosphate gives results resembling the red fluorescent variety of zinc-beryllium silicate in many respects, and cadmium borate can be used in conjunction with other powders to emit a warm white colour. These powders are excited by the short-wave ultra-violet radiation in the low-pressure mercury-vapour discharge, the result being increased luminous efficiency of the tube as a whole and good colour rendering.

In 1946, a further step forward occurred when the Research Laboratories of the General Electric Company, at Wembley, developed a new group of fluorescent powders under the name of halophosphates. The luminous performance of these powders is much better than that of those previously used and they are now being extensively employed all over the world. Later work to determine the most satisfactory formula for, and the correct structure of, the fluorescent powder, as well as the best way of depositing it and ensuring that it subsequently adheres to the inner surface of the tube have led, in combination with an improved design of cathode, to an increase in the life performance and have enabled the light output from the 5-ft. 80-watt daylight and warm-white tubes (such as are chiefly used in industry) to be increased by 12½ per cent.

A contributory factor to this development is the close control that is now exercised over the structure and purity of the fluorescent powder. It has been found, for instance, that the particles, of which the powder is composed, must not be all of the same size, but must vary within well-defined limits of the order of ten-thousandths of an inch. Further, the different sized particles must be evenly distributed throughout the powder. Fig. 3, Plate XXVII, shows the apparatus, which is being used in the General Electric Research Laboratories, to measure the particle size. It consists of determining the resistance offered by a bed of powder of specified thickness when air at a known pressure is pumped through it. Other equipment enables the composition and crystal structure of the material to be determined by X-ray analysis. It has also been found that the luminous performance of a powder is considerably modified by the presence of traces of impurities of the order of a few parts in a million. Accurate chemical and spectroscopic methods have therefore been developed for detecting and controlling the amounts of these substances.

As is well known, the colour of the light emitted by a fluorescent tube is another factor of importance. For instance, all tubes of the same colour designation must have the same appearance when operating and must also have the similar colour rendering properties. Although the eye is extremely sensitive, it is incapable of accurately assessing quantitatively light and colour. One of the most important pieces of work carried out at Wembley has therefore been the development of a "physical eye" photometer and colorimeter, which enables colour characteristics to be measured accurately and quickly. This instrument, which is shown in Fig. 4, Plate XXVII, being used in conjunction with a 12-ft. light integrating sphere, consists of a series of specially-shaped masks arranged round the periphery of a wheel. These masks can be located in turn in the plane of the spectrum so that they attenuate the coloured light in it in suitable proportions. The lamp under test is arranged so that it illuminates a white magnesium oxide surface, which acts as a diffuser. After the luminance of this surface has been measured it is replaced by a coloured surface, the luminance factor of which can then be determined when it is illuminated by the same lamp. To measure luminous flux the lamp is set up in a photometric integrator, which is so arranged that its window occupies the space normally taken by the magnesium oxide surface.

An important practical problem in the manufacture of fluorescent tubes has been to devise the best way to deposit the powder as well as to ensure its permanent adherence to the inner surface. Deposition can be effected in many ways and a number of binders are also available, which maintain the powder in even suspension and cause it to adhere to the tube before the latter is baked. The General Electric Company now carry out the coating process by forcing the suspension into the tube hydraulically and allowing it to drain by gravity, thus producing a uniform layer, which is free from blemishes. This operation is facilitated by the use of a binder with good film-forming and flow properties, which is dispersed by heat during the baking process. The result is that the powder is maintained in intimate contact with the internal surface of the tube.

Investigations, which have recently been carried out into the behaviour and functioning of the cathode, have been largely responsible for the longer life and improved performance of the new fluorescent tubes. Superficially, the cathode is a simple entity consisting of a coil of tungsten which contains and is coated with a thermionically emissive compound. To ensure satisfactory operation, however, careful attention must be paid during its production to its shape and dimensions, as well as to the chemical and physical properties of the coating. Much work has therefore been done to determine the conditions and requirements necessary to ensure the necessary control during actual manufacture.

As regards production, Osram fluorescent tubes are manufactured in works at Shaw, near Manchester. These premises have recently been equipped

DEVELOPMENT AND MANUFACTURE OF FLUORESCENT TUBES.

GENERAL ELECTRIC CO., LTD., LONDON.

(*For Description, see Page* 388.)

FIG. 3. MEASURING PARTICLE SIZE OF FLUORESCENT POWDERS.

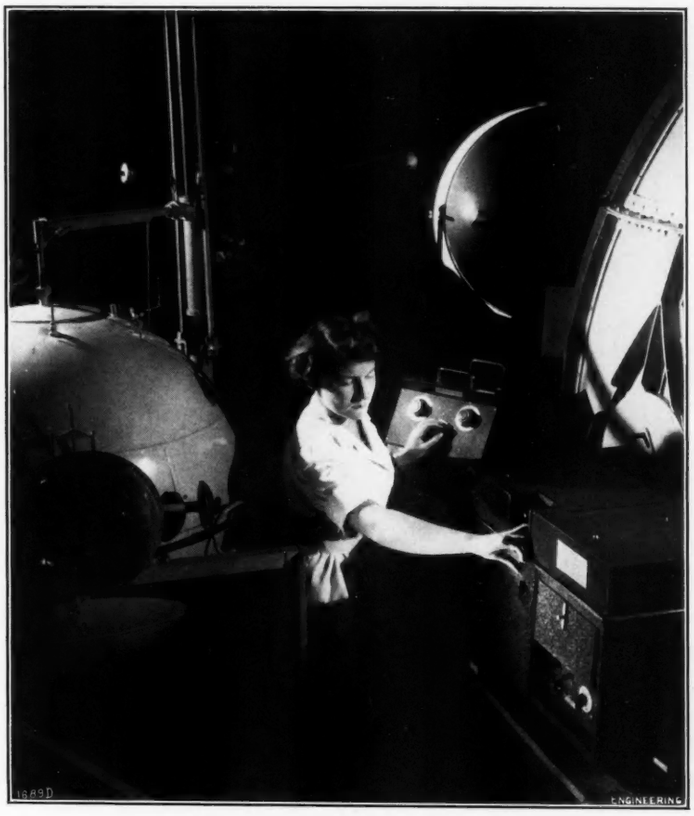


FIG. 4. "PHYSICAL EYE" PHOTOMETER AND COLORIMETER.

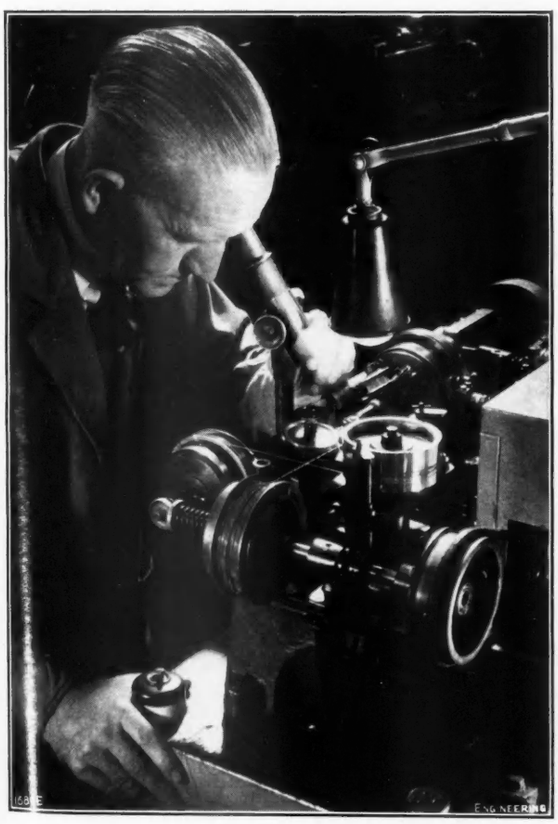


FIG. 5. PRODUCTION OF COILED-COIL TUNGSTEN WIRE FOR CATHODES.

FIG. 6. MULTI-HEAD CATHODE ASSEMBLY MACHINE

(*To face page* 388.)

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 391.)

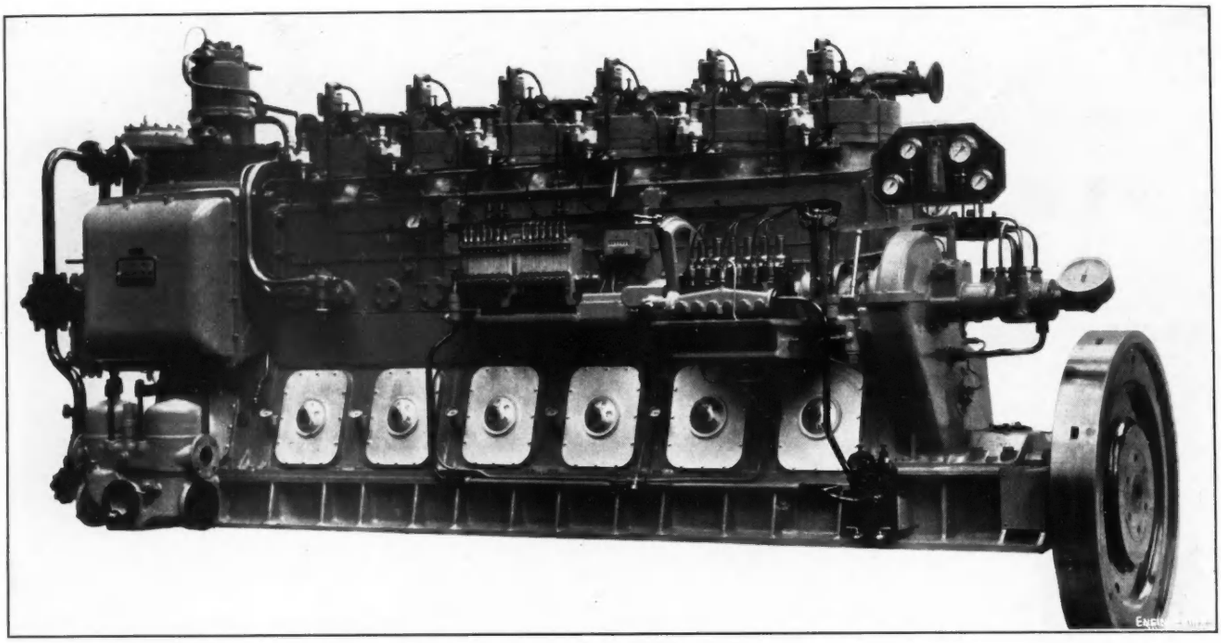


FIG. 128. 600-B.H.P. INDUSTRIAL DIESEL ENGINE; BRITISH POLAR ENGINES, LTD.

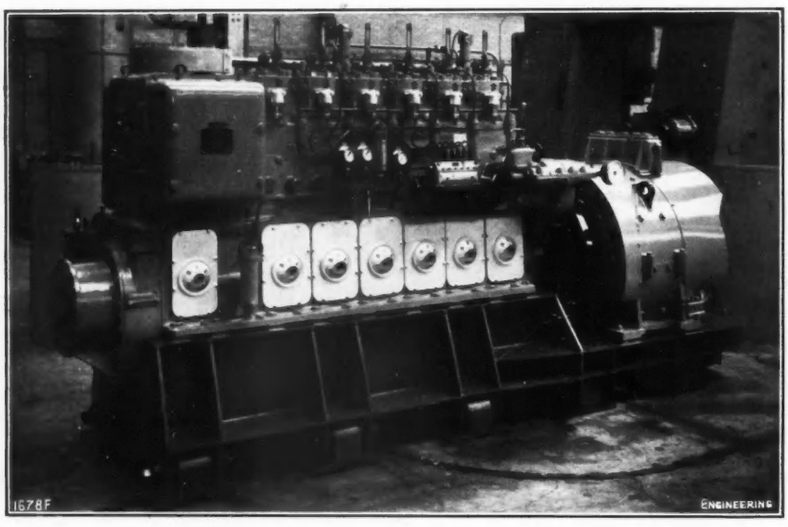


FIG. 129. MARINE AUXILIARY GENERATING SET; BRITISH POLAR ENGINES, LTD.

FIG. 130. HIGH-SPEED PLOTTING TABLE; DOBBIE McINNES, LTD.

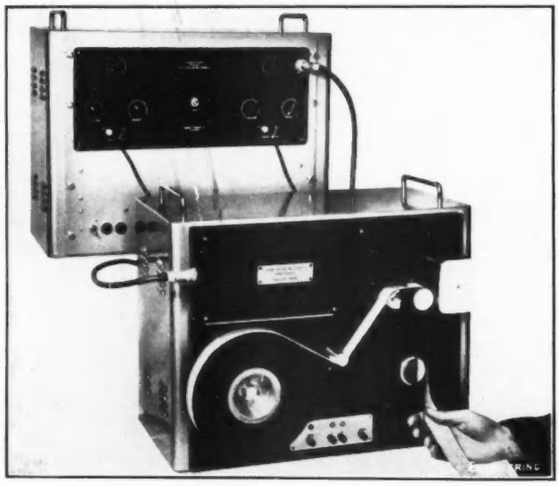


FIG. 131. HIGH-SPEED RECORDER; DOBBIE McINNES, LTD.

FIG. 132. 60-H.P. "POWER PACK"; SENTINEL (SHREWSBURY), LTD.

(*To face page* 389.)

with modern machinery, which enables the new techniques just mentioned to be translated into practice; and also renders it possible for quantity production methods to be used. In this connection mention may be made of the way cathode production, fixing and coating are accurately controlled. The coiled-coil wires used for the cathodes are produced on special coiling machines, which work to limits of a few ten-thousandths of an inch; one of them is illustrated in Fig. 5, Plate XXVII. The cathodes are then fixed to nickel lead-in wires on the multi-head automatic machine illustrated in Fig. 6, on the same Plate. This machine is also used for coating the cathode automatically and controlling its temperature to within 1 deg. C. At the same time a close check is maintained on the fluidity of the coating material and all atmospheric dust is eliminated. Exact timing and mechanical precision enable an amount of coating correct to within 0·00004 oz. to be applied. As a result of this method of manufacture, combined with the use of a mixture of the exact formula and structure, any tendency for the ends of the tube to blacken has been removed.

The rate of production has been increased and performance improved by the use of a new design of automatic vacuum pumping machine, one of which is illustrated in Fig. 1, opposite. In the manufacture of fluorescent tubes it is not only necessary to pump out the air from inside them, but also to remove the considerable volume of gases from the component parts. To do this, a development in high-speed exhausting, known as mercury dosing, is used in the new machine. This consists of introducing tiny globules of mercury into the tube at pre-determined intervals during the pumping operation, which greatly reduces the time necessary to obtain the necessary high degree of vacuum. Another advance in the production of fluorescent tubes is the automatic stabilising machine illustrated in Fig. 2, opposite. In this, the correct degree of activation in the cathodes is produced and the striking voltage is stabilised by a complex system of voltage-regulating gear so that there is no variation in the finished product. The tubes are delivered to the machine by the conveyor visible on the left and are taken away by that on the right.

THE BRITISH ASSOCIATION MEETING IN LIVERPOOL.

(*Continued from page* 373.)

Electronic Methods in Telephone Switching.

Professor G. W. O. Howe occupied the chair in Session B of the meeting on Friday, September 4, when the first paper taken was one by Mr. L. J. Murray on "The Use of Electronic Methods in Telephone Switching," which we commence to reprint on page 413 of this issue. After presenting his paper, Mr. Murray demonstrated the electronic system as applied to four telephones, using apparatus that might form a proportion of the actual equipment of an exchange.

The first speaker in the ensuing discussion was Mr. S. Welch, of the Telephone Switching Division of the Post Office Research Station at Dollis Hill, London, N.W.2. Mr. Welch said that while electro-mechanical telephone systems undoubtedly gave good service, improvements in technique were always sought. There appeared to be an opinion in the telephone industry that the fundamentals of mechanical switching were nearing their peak of development and any radical change in the electro-mechanical switching art was unlikely. While the mechanical switches themselves had reached a high stage of efficiency, it would appear that metal-to-metal contacts for application to telephone switching were not so advanced in development and their performance was by no means as satisfactory as could be wished. Thus it was timely that the possibilities of electronic switching should be investigated and the paper was a valuable contribution to the literature. As the author had stated, we might have electronic control with electro-mechanical speech path, or a wholly electronic system. The ultimate choice between these two must be influenced by such factors as cost, reliability, and possible caution in introducing new techniques in areas already familiar with well proved electro-mechanical switching. The cost of electronic switching was difficult to determine at the development stage, but he suggested that the switching and line plant costs should be integrated. A wholly electronic system using multiplex transmission and four-wire switching would permit economies in the local line plant as the switching system must incorporate necessary amplification in the speech path in the exchange. He asked if the author would regard this as a considerable advantage to be realised from wholly electronic switching, particularly as the line plant normally cost a great deal more than the switching plant. He agreed that any advantage from such integrated costs would take a number of years to realise.

Reliability of electronic equipment for telephone exchanges with a probable life of 20 to 30 years was also difficult to assess at this stage, but it could be said that the deterioration with time of electro-mechanical devices, particularly of metal-to-metal contacts, was a serious factor with no counterpart in electronic switching, and the reliability of electronic equipment should be at least as good, and probably better, than electro-mechanical. He asked if the author would agree that this point also was in favour of wholly electronic exchanges. It was necessary, however, to appreciate the practical difficulties of a commercial organisation selling new techniques to administrations well versed in electro-mechanical switching and with considerable capital laid down in plant, and from this aspect sympathy might be felt with the caution of introducing the semi-electronic system first, if only as an interim stage. This attitude must also be influenced by the transistor, which, when available, would reduce the admittedly high power consumption of wholly electronic exchanges, and might also reduce the number of hot-cathode valves which gave rise, perhaps, to the greatest number of faults in electronics.

An important possibility of multiplex working in wholly electronic switching was that individual multiplex selectors could be dispersed and located in manholes or cabinets near local concentrations of subscribers. The dispersed selectors could then be connected to the "main" exchange by coaxial lines worked time division, or frequency division, multiplex. This would reduce the length and expense of subscribers' line plant. He inquired whether the author would agree that this possibility should give weight to the adoption of wholly, instead of semi, electronic switching. The author, Mr. Welch continued, rightly stressed one of the main potential advantages of electronic switching, namely, speed, and pointed out the possibility of keysenders, instead of dials, at the instruments to speed up the dialling process to take advantage of the speed of electronics. If, however, the keysender transmitted the number information as coded voice-frequency pulses, he wished to draw attention to a serious problem which might arise, namely, that of signal imitation by speech or room noises in the caller's microphone which would be connected through to the switching equipment before and after keying and between each key operation. Adequate guard against this might require a frequency band, say from one to two kilocycles per second from the available spectrum, leaving relatively little for the signalling, which would lead to narrow band signalling filtration and expense. This, of course, could be overcome by asking the subscriber to operate keys at the start and finish of keysending, so as to isolate the microphone, but this would admit the danger of the subscriber forgetting to operate the start and finish keys. He asked for the author's views on this and whether he visualised direct-current keysending to overcome the problem. Another interesting possibility of the speed was built-in testing facilities. The equipment could be tested stage by stage as the setting up of the call proceeded, thus eliminating routine tests and automatic testing routiners. This factor might well have considerable influence on the costs, particularly on annual charges.

Dealing with more specific points in the paper, Mr. Welch referred to the statement that neither wiper and bank contacts nor relay-type contacts attenuated or distorted speech frequencies, whereas electronic devices had a greater liability to do so. This was true, but mention, he thought, should also have been made of the fact that metal-to-metal contacts were more subject to complete failure, particularly in dusty and corrosive atmospheres. Referring to Fig. 4, the speaker pointed out that the connection was not released until both subscribers had cleared. This was unusual as the British Post Office practice was to release when the caller cleared, and would appear to give rise to undesirable consequencies, i.e. both called and calling subscriber held. Was this, Mr. Welch asked, regarded as a desirable new facility, or had the condition been dictated by the arrangements of the system. Referring, in conclusion, to Fig. 8, Mr. Welch asked if bounce of the A contact would not give trouble.

The author, in reply to Mr. Welch, thanked him for his pertinent remarks on some of the more controversial points. He gathered that Mr. Welch was of the opinion that the full electronic system would prove to be preferable to the semi-electronic system, and this showed a correct habit of mind in the electronic switching engineer, although certain points had to be taken into account. For instance, while agreeing that a full electronic system, especially of the multiplex type, might have a considerable effect on the transmission characteristics required for the lines, as Mr. Welch had suggested, the transmission network was by far the most important part of the cost of the telephone system and therefore that factor made for the retention of the present type of transmission layout. With regard to reliability, Mr. Welch had made the point that the metal-to-metal contacts might be liable to sudden failure, but this possibility was largely due to the atmospheres in exchanges which were dusty. With the increasing practice of using air conditioning in exchanges and the enclosure of the equipment, that factor tended to become of less importance. Although there might be possibilities in decentralisation, his own experience had been that if any subject recurred continually in a switching problem it was that of decentralising exchanges. It was possible that full electronic switching might help decentralisation, but, at the moment, it appeared that the cost factor also operated there. It was correct to say that the ultimate advantage from electronic switching would not be felt until the present subscriber's telephone set had been replaced by a fast-sending mechanism, but he would not speculate as to what that might be. One form of keysending had already been described in the *Bell System Technical Journal*, but Mr. Welch was quite right in pointing out the troubles that were likely to arise with equipment of that type. It was probable that ultimately a subscriber would be able to pick up his telephone and speak into it the number he required and it would then be set automatically by the voice impulses, but that would mean the introduction of a standard international speech and intonation! Regarding the specific points raised by Mr. Welch regarding the paper, it was possible that in it he had given a somewhat misleading account by saying that the connection was not released until both subscribers had released, whereas in fact on either subscriber releasing he was free to make another call or to be called. In connection with relay bounce and the impulse circuits in Fig. 8, the C.R. network introduced a delay feature which was intended to overcome these effects.

The time available having then elapsed, the chairman adjourned the meeting for a short interval, after proposing a vote of thanks to the author.

Television Broadcasting in Colour.

Session B was resumed in a larger lecture theatre, and the Chairman, Professor Howe, called on Mr. F. C. McLean, C.B.E., B.Sc., M.I.E.E., Deputy Chief Engineer of the British Broadcasting Corporation, to present his paper entitled "The Application of Colour to Television Broadcasting." This paper will be reprinted in a forthcoming issue of Engineering. The reading of the paper was interspersed by a number of interesting demonstrations and was followed by a discussion.

The first speaker inquired whether the need to produce a compatible system in colour television would be likely to result in a worse system than a

straightforward colour system. To this question the author replied that the answer was probably in the affirmative, but whichever system was employed it would not be so good as the very best possible. The latter would involve very heavy expenditure on apparatus, require a great deal of wavelength space, and would be very difficult to manage. This was probably too high a price to pay. As they had done in the case of black and white television, they had to produce the best compromise and he did not think it would be appreciably worse if the picture were compatible.

To a member's question whether a two-colour system would be practicable, Mr. McLean replied that it had been suggested some time ago that a reasonably good picture could be obtained with two colours only, but the general opinion was that it would not be good enough and that the full three-colour system must be used. Another member asked if the question had ever been raised of obtaining an additive picture by using a colour screen in front of a black and white tube. To this question, Mr. McLean replied that this was the basis of the C.B.S. system, which employed a white tube with a rotating three-colour filter in front of it. If, however, the speaker meant that the screen itself should be of three colours instead of being composed of phosphor dots, he thought that would be rather difficult and did not know whether it had been considered. Another speaker said he understood that the Americans transmitted a black signal, as opposed to the white signal used in this country, and thought that the former had certain advantages from the point of view of interference. In reply, Mr. McLean said the Americans were transmitting a negative signal whereas we were transmitting a positive signal, but the video signal was the same. The Americans modulated downwards whereas we modulated upwards. While the American system had some advantages from the interference point of view it had certain disadvantages with respect to synchronising. However, the respective systems had been decided upon on a monochrome basis and each had to make the colour system fit in; the Americans had some advantages and we had others. The European countries were divided, some having positive modulation and some negative.

The last question asked was whether the author could foresee any great difficulties regarding the installation and servicing of colour-television receivers, as they seemed to be so much more complicated than the black and white system and it was possible that the normal television service engineer would not have sufficient knowledge. Mr. McLean replied that colour-television receivers would certainly be much more difficult to service than black and white receivers and the training of service men to handle them would be quite a serious problem; it might, however, be found to be no worse than the problem which existed with the advent of black and white television. Radio service men for years had handled only sound receivers, but they had been able to deal with television receivers and it would seem that the change in technique between sound and television was greater than that between monochrome and colour.

This concluded the business for the session and the meeting was adjourned after a vote of thanks to the author had been proposed by the Chairman and carried enthusiastically by the members.

When the meetings were resumed on the morning of Monday, September 7, the programme of Section G was again divided into two parts. Session A comprised a joint meeting with Section J (Psychology), under the chairmanship of Professor L. S. Hearnshaw, to consider the problems involved in time and motion study.

Time and Motion Study.

The first paper of the session, by Miss A. G. Shaw, entitled "The Use of Motion Study in Increasing Productivity," was a description, illustrated by films, of investigations of motion study made in various industries, laying particular emphasis on the human problems involved in altering established methods of work. Miss Shaw began her paper by pointing out that one of the major industrial problems of our time was to achieve greater production at a lower cost and there were a number of ways in which this could be done. Leaving aside the development of new and cheaper materials, the three main approaches were better machinery and equipment, increased effort on the part of the operator and more effective methods of working. Motion study—Miss Shaw said she deprecated the use of the term "time and motion study"—was concerned with the third of these approaches.

Motion study, continued Miss Shaw, implied the study of the needs and problems of the operator at work and while it made use of a number of definite techniques for recording and examining methods, this was only one aspect of the subject. No method of work was of the slightest use until it was in operation in the factory and in most motion-study work quite as much, and often more, time had to be spent on the problems of changing methods and habits of the operators as was spent on devising the process improvements.

Each motion-study investigation was unique and was concerned with one set of people in one particular set of circumstances. Each study must, therefore, begin by examining the whole field of the investigation. For example, it was important to know from the beginning whether short term or long term results had to be achieved; for example, a 25-per cent. improvement immediately could be more valuable than a 50-per cent. improvement six months later, when the market might have been lost. On the other hand, where there was unlikely to be any change in supply and demand for a long period, it would almost certainly be worth while to make the maximum possible improvement, although that might take a long time to plan and to execute. A further consideration was the question of the relative priority of machine and/or operator efficiency, for the elimination of unnecessary labour would often bring about a greater improvement than the speeding up of a particular machine.

In any given investigation, it then became important to know whether the quantity of work fluctuated seasonally or in any other way, whether it would be possible to allow the production of a larger quantity of work by the same number of operators, or whether saving would have to take the form of a reduced labour force producing the same quantity as before. In this latter case, arrangements had to be made for the placing of surplus operators on other suitable work as it becomes available and before the operators were redundant, or for effecting the reduction by the normal wastage of labour.

Throughout any motion-study investigation the co-operation of both worker and supervisor was essential. Most opposition comes from a lack of understanding, but if the object and methods of motion study were fully understood and the benefits of the improvements made self-evident, co-operation was more likely. Managers, supervisors and operators should be trained to understand simple motion study and should be encouraged to join in its application so that every improvement was the result of team work.

Miss Shaw concluded her paper with a film, "The Full Application of Motion Study," showing how and what improvements were attained in a biscuit factory, the film contrasting the original and final processes employed in the factory. (On the following afternoon, Tuesday, a party of members drawn from both sections visited Miss Shaw's establishment at Cheadle, Cheshire, where they were shown equipment and models of factory layouts that had been employed during particular studies. Members also saw four more films showing the methods of motion study adopted, and the results achieved, in a variety of industrial situations, and were shown the analysis charts which were built up from the films to be used when examining each process for unnecessary movement or action.)

After a short adjournment, Mr. Winston Rodgers delivered his paper "Techniques in Motion and Time Study." in which he surveyed and criticised the various techniques and procedures that are available and have been adopted by engineers. The author began by pointing out that the motion study engineer was engaged in the qualitative and quantitative analysis of work. In both these broad spheres of activity he had developed certain mechanics or procedures of work which, by and large, had served his purpose and enabled him to render a useful industrial service. An examination of the practices showed that the qualitative or fact-finding procedures were no more than simple exercises in their purely mechanical content, but the benefit to be derived from their use was still dependent on the ability of the user. Assuming that the fact-finding techniques were capable of providing information adequate for practical purposes, considerable reliance must still be placed on individual judgment and experience in interpreting the facts and engineering a working method. There were as yet, continued Mr. Rodgers, no well-defined steps in the building-up process and few norms were available for comparative purposes. Thus, when it was stated that a 50 or 100 per cent. increase in output had been achieved by the application of motion-study techniques, this improvement might mean no more than lifting the original output from "very poor" to "poor." The increase, however, may still be sufficiently impressive to lull management into a sense of satisfaction.

To this lack of objectivity must be added, at least at the industrial or working level, an inadequate association between the findings of the experimental industrial psychologist, the practising physiologist and the motion-study engineer. An association whose activities may well bridge this gap, Mr. Rodgers suggested, is the Ergonomics Society. When attention was directed solely to stop-watch studies, the shortcomings of present-day practices became very serious. There were, for example, the vexed questions of the reliability to be attached to the subjective assessment of an operator's working performance, the nature and value of fatigue as well as other similar allowances. His criticisms had not been made to deny the very real contribution which motion and time study has made to increasing productivity, but rather to emphasise the need for research and the closer co-operation between research workers and engineers where their fields of activity merged.

In opening the discussion, Mr. D. Wallis, dealing with motion and time study as a practical tool and also as a technique with certain scientific limitations, said the question of terminology was a most important one and he had used the term "motion and time study" advisedly as method study should always precede time study, logically and practically. Both speakers had differed in the use of the term: Mr. Rodgers had recommended "methods engineering," and there they had the dual opportunity of judging the scientific worth of the discipline and its practical application and results because they had seen by the film that the most striking results could be obtained. On the other hand, they had heard from Mr. Rodgers that the reason for that increase might not be due to any extraordinary virtue of the discipline, but rather to the extraordinary virtue of the practitioners or to the extraordinary inefficiency of industry. Ways had to be devised of overcoming resistance to change, but constructive criticism reflected a healthy outlook on the subject, particularly if it prompted further research. Predetermined motion and time systems should be examined most carefully, both by potential users and by research workers. There was a great need for more intelligent interest in the topic generally, and for more laboratory and experimental research into the analysis of perceptual and movement skills. For example, should an operator working quickly use the same pattern of movement as when he was working slowly? Were the shortest movements necessarily the swiftest and the least fatiguing? Probably the most important and distinctive contribution that an occupational psychologist could make in the field of human relations in industry, concluded Mr. Wallis, was to promote the right social climate in which to fit the new methods, or even to have the opportunity of trying them out.

The next speaker, Mr. K. F. H. Murrell, referring to the question of terminology, said the practice of motion study had suffered very considerably in the past from the fact that it was tied up in most workers' minds with time study, which in turn was tied up with the question of wages, either for piece work or for various bonus schemes. In fact, at a recent conference a very strong attack had been made on time study, and it had been quite clear that the speakers were confusing rate fixing with the

technical assessment of the method. In his view, the two must be separated, and the people who designed the methods should not also fix the rates. In that way, it was possible to obtain the operator's confidence much more easily. Turning to another point, Mr. Murrell continued by stating that it could be shown that successive movements of an operator were not independent of each other; laboratory research had shown that what was done before a particular movement had a profound effect on the duration of that movement. The most important problem with which research workers were faced at the moment was to ascertain how to translate what was done in the laboratory into terms of the work done on the shop floor.

Professor G. P. Meredith, referring to the relation of psychology to the engineer and to motion study, said the pure psychologist, who had not had an industrial training or any industrial experience, should feel very diffident about approaching the industrial field, but his diffidence could be diminished if the basis of his approach were made clear. At present, the basis of his approach should be, to a large extent, that there was a vast field of human behaviour requiring study and with ample data for the psychologist, and possible inferences having a profound bearing on pure psychology. The role of the psychologist should be to investigate that field without any prior assumption that he would be able to help industry, although if he could it would be all the better.

Mr. R. J. Bartlett said that it would be of interest to know whether the psychologists who were really in touch with the factories found considerable difficulty in getting very efficient workers to pass from an old plan to a new one, and whether the old workers were ever able to reach the efficiency of a new operator who had not known the old method. The breaking of habit was one of the toughest propositions to be faced, because it meant bringing back into volitional control actions which had been purely automatic.

Miss Shaw, in reply, said they experienced a very great deal of difficulty in changing habits and for that reason a point was made of making the new methods entirely different; in fact, sometimes a deliberate change was made although it was not actually necessary, in order to be able to make the change of habit easier. The question of whether the person who was most efficient in the old method would be most efficient in the new was bound up with a great deal more than habit. There was also "know-how" in connection with a job and it was not desirable to have to teach that to a new operator. More important still, was the fact that if the job was going to be done with fewer operators it would be grossly unfair to bring in a new operator to act as an additional competitor.

Finally, Miss Shaw protested strongly against the use of the term "methods engineering." Motion study was not engineering, but involved the handling of people from beginning to end; there was a major danger in thinking that it was only a question of gadgets. Methods engineering was bad, but human engineering was worse.

Mr. Rodgers, in his reply, agreed with Mr. Murrell that motion study should be entirely divorced from time study and the question of wages. On the question of methods engineering, reference to Chaucer would show that "engineering" meant "planning, devising or creating," and he was using the word, not in the restricted, limited sense, but in the widest possible interpretation.

On the proposal of the Chairman a vote of thanks was accorded to Miss Shaw and Mr. Rodgers, as well as to Mr. Wallis for opening the discussion, and the session was then terminated.

(To be continued.)

IRON AND STEEL PRODUCTION IN UNITED KINGDOM.—Statistics issued by the British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.1, show that steel production in this country, although affected by holidays, nevertheless averaged 291,400 tons a week. This was the highest August figure ever recorded and compares with a weekly average of 279,500 tons in the corresponding month of 1952. The output of pig iron, which also constituted a record for the month, averaged 204,400 tons a week, against 201,900 tons a week in August, 1952.

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

(Concluded from page 358.)

AN exhibit which arrived at Olympia within the last few days (the exhibition closed on September 17) was the mobile laboratory of Smiths Industrial Instruments, Limited. Earlier this year, it made a tour of Europe to test coach heating and ventilating units. The laboratory comprises a Leyland Royal Tiger chassis with Duple bodywork and interior seating layout, some of the seats being removed and replaced by the test equipment. A water heater and air heater are being demonstrated within the coach. The air heater, which it is considered will be useful in the field of cold starting for Diesel engines, has an output of 50,000 B.Th.U. per hour for a fuel consumption of 3¼ pints per hour. The fuel used is kerosene and the size of the unit is approximately 9 in. in diameter by 20 in. in length. We expect to describe this unit in a later issue of ENGINEERING.

600-B.H.P. INDUSTRIAL DIESEL ENGINE.

The engine shown in Fig. 128, Plate XXVIII, is one of two that were exhibited by British Polar Engines, Limited, Helen-street, Govan, Glasgow. It is known as the M46I, has a bore of 250 mm., a stroke of 420 mm. and a scavenge pump; this particular one is for industrial application although a marine version of the same engine is made. It develops 600 brake horse-power at 400 r.p.m. and is of the single-acting two-cycle type. The main features of the engine are common to the three sizes at present being made by this company, namely, the model M with a bore of 340 mm., the model I mentioned above, and the model E, with a bore of 180 mm., which is shown in Fig. 129, Plate XXVIII. The scavenging system adopted is based on a number of patents which facilitate the use of a symmetrically designed piston top, which eliminates the risk of creating high local stresses and gives a combustion chamber requiring a very low scavenge-air pressure. This is said to give high scavenge efficiency with the minimum air consumption and a favourable fuel consumption.

The scavenge air is delivered by a pump driven from the main crankshaft at the forward end. The large cover-plate which can be seen at the forward end in the illustration houses the suction and delivery valves of the pump. The bed-plate of the engine is made in either cast iron or steel and white-metal-lined bearings are fitted. The thrust bearing is of the Michell type and bolts directly on to the bed-plate. Both the crankshaft and thrust shaft, to which the cast flywheel is fitted, are forged steel and a flywheel with teeth cast around its periphery to accommodate turning gear may be fitted in place of that shown. The cylinder stools are made from either cast iron or steel and doors are fitted on each side for access. The cylinder blocks are arranged in pairs and fitted with liners made from a close-grained cast iron. The liners are free to expand longitudinally and bolts extend from below the main bearings to the top of the cylinder blocks.

The connecting rods are forged and are drilled longitudinally to convey oil to the top-end bearings and for piston cooling. The piston and piston rings are made of a special cast iron. The cylinder cores are built in two parts with a space for cooling water and ports for the starting-air valve, relief valve and fuel-injection valve. The fuel valves are of the automatic needle type and the valve bodies carry their own fuel filters. The fuel pump, which is visible on the right in the illustration, is driven through a special coupling which prevents the delivery of fuel until the engine is rotating in the desired direction. An overspeed governor acts on the fuel-pump suction valves. The manœuvring gear for the engine comprises a hand-operated valve for the starting air, a lever which sets the camshaft and the manœuvring valve in the correct position for forward or reverse rotation and stopping, and a speed control lever, all of which are grouped together. The starting valves are designed so that they cannot open if the pressure in the cylinder is higher than that of the starting air. The starting-air compressor is of the two-stage type and is driven in tandem with the scavenge pump. It delivers air at 350 lb. per square inch to a bottle type of reservoir. The cooling-water pump is driven from the crankshaft, and the lubricating oil pump, which is of the gear type, is driven through gears off the forward end of the scavenge-pump shaft.

Thermometers are fitted to the cylinders for measuring exhaust gas, piston-cooling outlet and circulating-water outlet temperatures, and one is fitted at the piston-cooling inlet to the engine and one in the circulating-water system. A tachometer is fitted so that it is visible at the control platform. The fuel consumption of this engine is 0·370 lb. per brake horse-power per hour at full load and 0·382 lb. per brake horse-power per hour at half load. The weight of the engine is about 21·8 tons and its overall length is 17 ft. 11½ in.

MARINE AUXILIARY GENERATING SET.

A marine auxiliary generating set made by the same company is shown in Fig. 129, Plate XXVIII. It is their type K46E and is designed to produce 200 kW on a continuous rating. Like all the British Polar engines, it is designed on the two-cycle single-acting principle. The bore is 180 mm. and the stroke 300 mm. The engine is mounted with the generator on a combined bed fabricated from steel plate. The engine, which is a six-cylinder unit, develops 330 brake horse-power at 600 r.p.m. with a fuel consumption at full load of 0·386 lb. per brake horse-power per hour. An interesting feature claimed for this auxiliary unit is the resilient mountings, which are installed to prevent the transmission of vibrations from the engine to the ship's hull. The layout and other basic features of the engine are similar to those in the M46I described above.

HIGH-SPEED PLOTTING TABLE.

Dobbie McInnes, Limited, 191-3, Broomloan-road, Glasgow, S.W.1, showed among the exhibits in Fig. 130, Plate XXVIII, the high-speed recorder shown in Fig. 131, on the same Plate, a poise meter and their newly-developed Diesel indicator valve. The plotting table was first designed for a special purpose and has since found application in other fields. It has a working table, on which the recordings are plotted, of 18 in. by 30 in. and the equipment, which is completely self contained, is made for operation on a 50-cycle mains supply. The single pen used for plotting, which can be seen in Fig. 130, attached to its supporting arm, is driven by two servo-motors in two directions, representing the X and Y cartesian co-ordinates, simultaneously. The position of the pen is controlled by signals in the form of direct-current voltages, which are proportional to the ordinate and abscissa. The maximum speed of movement of the pen is 15 in. per second and its dynamic accuracy is approximately $\pm 0{\cdot}2$ per cent. Constant-speed operation in either direction can be obtained and the table is equipped with automatic safety devices and resetting units. The size of this instrument is 46 in. by 32 in. by 37 in. high and it weighs 650 lb.

HIGH-SPEED RECORDER.

The recorder illustrated in Fig. 131, Plate XXVIII, performs the functions of a cathode-ray oscilloscope and moving-film camera. It provides recordings on electro-sensitive paper of low and high frequency variations in voltage, from zero to beyond 2,000 cycles per second. The Ferranti fixed-stylus method of recording is employed, in which there is no attenuation of the recorded signal with an increase in frequency, and no variation in the relationship between the recording and input signal at various frequencies. Square waves, saw-tooth waves and transients can be recorded up to and beyond 2,000 cycles, and phase differences between signals can be measured. The upper frequency limit is dependent upon the ability clearly to mark the sensitive paper at speed. The problem of inertia has been overcome by the use of 36 stylus points which do not move. These points are evenly spaced across the 35-mm. wide sensitive paper. As the input voltage rises and falls each stylus is energised and marks the paper. The paper speed is up to 20 ft. per second and the equipment is designed for operation on alternating-current mains. Both

ENGINEERING, MARINE AND WELDING EXHIBITION.

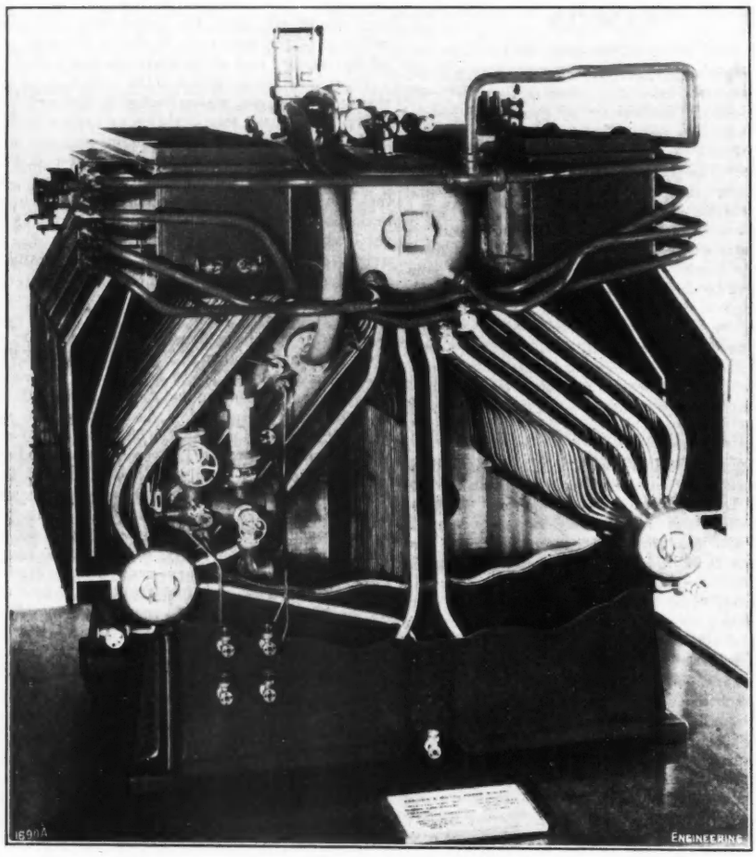


FIG. 133. MODEL OF CONTROLLED-SUPERHEAT MARINE BOILER; BABCOCK & WILCOX, LTD.

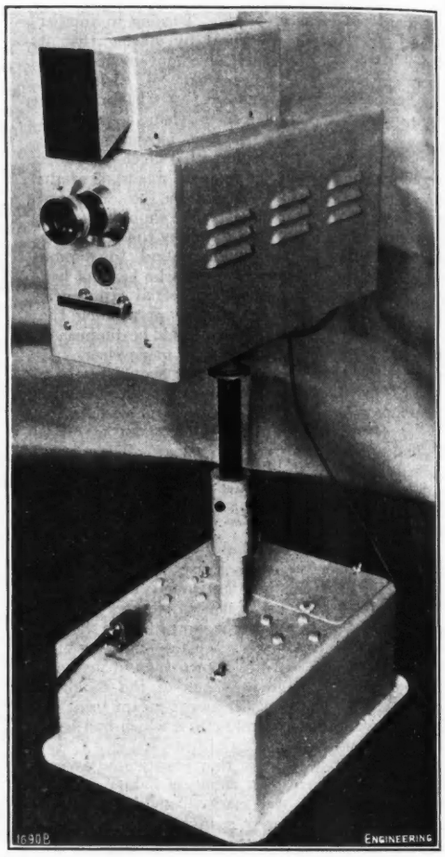


FIG. 134. TELEVISION TRANSMITTER FOR BOILER WATER LEVEL; BAILEY METERS & CONTROLS, LTD.

multi-channel and remote-control arrangements are also available with this equipment.

The Dobbie-McInnes Diesel-engine indicator valve which was also shown looks rather like the double-seated valve which was produced by them some years ago; the new valve, however, is of improved design, has no packing and is said to stand up to the hottest engine. It has a metal chuck for preventing slackening of the spindle by vibration. Both the body and spindle are stainless.

The poise meter, made by this company and also mentioned above, has been designed for measuring the viscosity of oil. It is named after the French scientist Poiseuille, who is famous for his work in this field. The major oil companies are at present using the instrument for remote recording and control of the viscosity of distillation products, etc. The instrument maintains an accuracy of $\pm 1\frac{1}{2}$ per cent. of the indicated viscosity. The design of the instrument is based upon the knowledge that the input voltage to an electric motor, which is driving a drag member rotating in a fluid, measures the viscosity. The motor, which drives the drag member, is associated with a thermostatically-controlled heat exchanger through which a continuous flow of fluid is passed. It controls the temperature within about ¼ deg. C. Within this limit a temperature-sensitive element senses any divergence from the mean value and automatically compensates the indicated result, giving a thermosetting accuracy of 0·2 per cent. The equipment is made to accord with the British Standard Flameproof Regulations.

60-H.P. DIESEL-ENGINE "POWER PACK."

Sentinel (Shrewsbury), Limited, Shrewsbury, were exhibiting two of their type 2-U two-cylinder Diesel engines; one is coupled to a Sigmund centrifugal pump and the other is fitted with a radiator and a power take-off. The output of this engine is

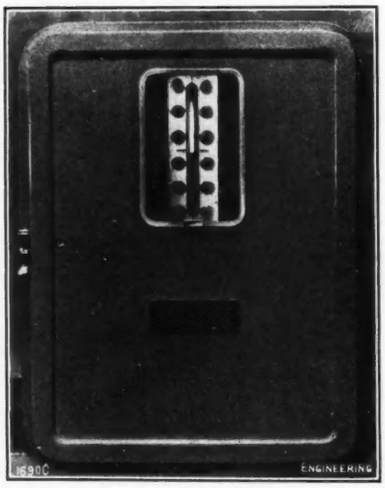


FIG. 135. TELEVISION WATER-LEVEL RECEIVER; BAILEY METERS & CONTROLS, LTD.

30 brake horse-power at 1,500 r.p.m. They also displayed a four-cylinder Diesel engine of the horizontal type with direct injection, a six-cylinder horizontal Diesel engine with an output of 93 brake horse-power at 1,500 r.p.m., and a type 4 P.U. power pack, which we illustrate in Fig. 132, Plate XXVIII.

The engine used in the power pack is the four-cylinder unit mentioned above. It has a bore of 4·75 in., a stroke of 5·25 in., and a capacity of 6·08 litres. The output is 60 brake horse-power at 1,500 r.p.m., and the fuel consumption is 0·40 lb. per brake horse-power per hour; this performance is based on a 12-hour rating at atmospheric temperatures up to 85 deg. F. and not more than 500 ft. above sea-level. The combustion system is of the direct-injection type employing a C.A.V. fuel pump and injectors. The injectors fit into cylinder heads of cast iron, which also carry the inlet and exhaust valves, the latter having hardened tips. The valves are operated by rocker levers through push rods and cam levers from the camshaft. The cylinder block is a single casting incorporating cast-iron liners of the dry type. The crankshaft is forged from chromium-molybdenum steel and nitrogen hardened. It runs in steel bearings lined with lead bronze and is fed with lubricating oil at a pressure of 45 lb. per square inch. A gear-type pump circulates the lubricating oil, drawn from the sump via a fine-mesh filter, through a full-flow type metallic filter to the bearings, and through a reducing valve to the camshaft and valve gear, where it is delivered at 10 lb. per square inch. The radiator fitted provides a cooling area for both the water and lubricating oil and a pusher type of fan is used. A 24-volt starting motor and generator are fitted.

The whole unit is mounted on steel runners with cross bracing, and a sheet-steel canopy covers the engine and fuel tank. The side panels are detachable, and an instrument panel, which can be seen in the illustration at the front right-hand end, is fitted. It carries the control lever, starter button, ammeter, oil-pressure gauge, and water-temperature gauge. The power take-off that is fitted has a Rockford over-centre type clutch and the clutch housing supports the outboard bearing of the drive shaft. The shaft is 2·25 in. diameter, and it may be used for direct drive or can be fitted with a pulley or sprocket wheel. A hand hole is provided in the housing for adjusting the clutch. The fuel tank

ENGINEERING, MARINE AND WELDING EXHIBITION.

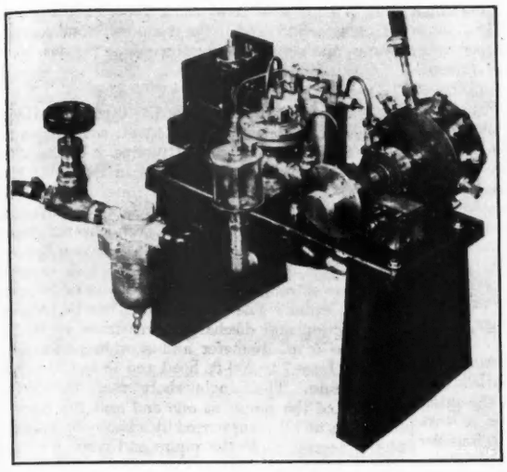


FIG. 136.

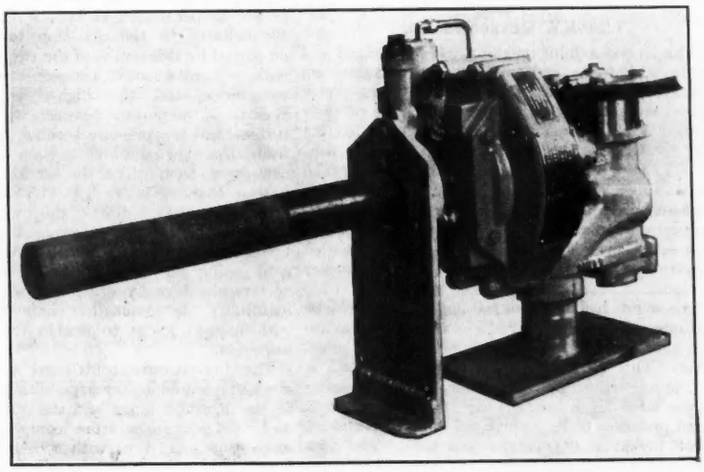
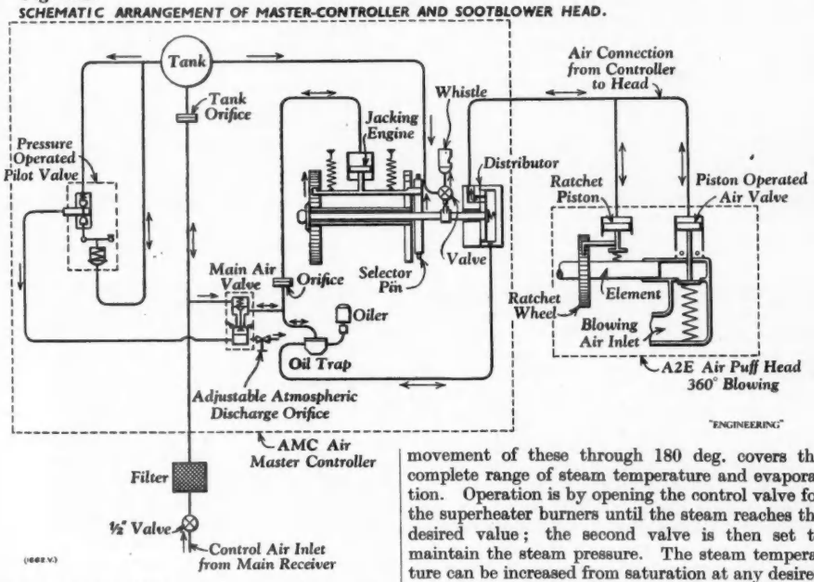


FIG. 137.

Fig. 138.
SCHEMATIC ARRANGEMENT OF MASTER-CONTROLLER AND SOOTBLOWER HEAD.



FIGS. 136-138. "AIR-PUFF" SOOT-BLOWER; BABCOCK & WILCOX, LTD.

holds 30 gallons and the net weight of the unit is 2,996 lb. The overall length of the runners is 6 ft. 8 in. and the width and height of the unit are 3 ft. 9 in. and 4 ft. 6 in., respectively. The distance from the base of the runners to the centre of the power take-off shaft is 1 ft. 10 in.

MARINE BOILER WITH CONTROLLED SUPERHEAT.

On the stand of Babcock and Wilcox, Limited, Babcock House, Farringdon-street, London, E.C.4, a number of boiler accessories and models were displayed. In Fig. 133, opposite, we show a model of a Babcock marine boiler of the divided-furnace or controlled-superheat type, designed to supply steam with any degree of superheat and allow at the same time any amount of saturated steam to be taken direct from the drum without endangering the superheater. It is a three-drum boiler with two furnaces separated by a water wall of stud-tube construction, which does not allow gas to pass from one side of the unit to the other. Oil burners in one furnace provide the heat for the superheater, which is screened by three rows of boiler tubes. An independent set of oil burners heats the saturated bank. Plunger burners in each furnace have their oil pressure controlled by two calibrated oil valves; movement of these through 180 deg. covers the complete range of steam temperature and evaporation. Operation is by opening the control valve for the superheater burners until the steam reaches the desired value; the second valve is then set to maintain the steam pressure. The steam temperature can be increased from saturation at any desired rate when warming the turbines and it can be lowered from 850 deg. F. to 650 deg. F. in less than a minute, should an emergency arise. Steam pressure can be raised in a short time by firing the saturated furnace. The superheater tubes are safeguarded against over-heating without the necessity of circulating steam through them. No desuperheater is required, and when saturated steam is taken direct from the drum the saturated burners require more oil while the superheat burners remain steady to keep the desired superheat steam temperature.

TELEVISION APPARATUS FOR INDICATING BOILER WATER LEVEL.

Figs. 134 and 135, opposite, show the transmitter and the receiver of the Levelscope, with the image of a water gauge on its screen, which was demonstrated by Bailey Meters and Controls, Limited, Progress-way, Purley-way, Croydon, its makers, on the stand of Babcock and Wilcox, Limited. It is believed that this is the first application of closed-circuit television for remote water-gauge indication commercially available in this country. It has been developed to facilitate the reading of gauges on modern boilers which have increased drum height. The makers state that closed-circuit television cannot give a false reading, as it shows either a true picture or nothing at all, when remedial action would have to be taken. The Levelscope consists of a television camera with a power pack incorporated, and a receiver which can be mounted wherever it is required. In some circumstances a rear-cell unit, which is clamped on to the water gauge, may be required. The transmitter and receiver are coupled by an ordinary coaxial cable and the equipment uses components which are readily available commercially. No special lighting is said to be required as the camera carries its own built-in ultra-violet lamp; this feature enables it to be operated satisfactorily in darkness.

"AIR-PUFF" SOOT BLOWER.

Another exhibit on this stand was the Babcock-Diamond Air-puff soot blower, illustrated together with its control unit in Figs. 136 and 137, on this page. It uses compressed air as the blowing medium. The use of air instead of steam offers a distinct advantage for installation in marine boilers as it provides a saving of make-up water. The blowing sequence becomes automatic after opening the valve. The schematic diagram, Fig. 138, shows the operating circuit of the master-controller and soot-blower. The normal boiler-cleaning cycle takes from 3 to 4 hours when blowers of this type are installed and it is claimed that no soot nuisance occurs on deck and boiler operations are not disturbed while cleaning is in progress. Air for the system is usually supplied by a compressor which discharges into a receiver of about 100 cub. ft. capacity at 125 lb. per square inch. The system is operated by the master-controller, which draws air from the receiver via the small pressure-control tank shown in the diagram. A selector within the control box comes into operation, after each soot-blower has rotated through a full 360 deg., and rotates the distributor head, causing air to be directed to the next soot-blower in sequence. The distributor head is provided with 12 tappings. If more are required a second head can be fitted and a three-way cock included in the circuit for change-over from the first distributor to the second. The nozzle pipe of the soot-blower, which is shown in the illustration with a threaded end, remains stationary for one minute after each discharge of air.

During blowing, the nozzles produce a series of puffs of one second duration, and while the receiver is being replenished the nozzle pipe is rotated by the ratchet piston and ratchet wheel through 17½ deg. until the full circle of 360 deg. has been completed. After the final soot-blower in the system has been operated a whistle blows until the air supply is shut off. The automatic operation of the system can be interrupted at any time during the cycle, to omit one of the blowers in the sequence or to repeat the period of blowing, by turning the knobs of the indicator dial. The master control unit has been designed to enable the compressor sup-

plying air to the system to work at a steady load throughout the blowing cycle. The blower elements used in this Air-puff system follow the design of the Babcock-Diamond steam soot-blowers.

1,280-KW Generating Set.

The largest exhibit on the stand of Harland and Wolff, Limited, Shipbuilding and Engineering Works, Belfast, was their 1,850-brake horse-power Diesel engine, which was coupled to one of their 1,280-kW alternators and is illustrated in Fig. 139, Plate XXIX. The eight-cylinder engine runs at 333 r.p.m. and operates on the four-stroke cycle. It is supercharged by a Napier exhaust-driven turbo-charger, and the alternator to which it is connected supplies three-phase current at 6,600 volts. The set is one of several ordered by the British Electricity Authority for their Blackpool power station.

The engine has a bore of 400 mm. and a stroke of 600 mm. The valve gear is enclosed and there are two inlet and two exhaust valves in each cylinder-cover. This four-valve type of cylinder-head is said to be particularly suitable for pressure charging as the large areas through the valves enable high mean pressures to be maintained without excessive boost pressures or cylinder pressures. The two inlet and two exhaust valves are operated in pairs by rocking levers, each lever acting on a guided yoke which bears on the ends of the spindles of the two valves. The valve ends of the levers are fitted with cam-like inserts of hardened steel and the top of the yokes, where these inserts bear, are Stellited. The lever fulcrum pins are carried in needle bearings. The pistons are oil-cooled and the discharge passes outside the crankcase to the lubricating-oil drain tank; a thermometer is fitted in each outlet. The fuel-injection equipment is the makers' latest type for this class of engine and it has a scroll plunger control. The fuel valves have lapped spindles with conical seats.

The lubricating-oil pump also supplies the oil for piston cooling. It is directly driven from the free end of the engine and delivers oil through a multi-tubular type of oil cooler fitted with a by-pass incorporating an oil-temperature control. An electrically-driven pump is fitted for priming the lubricating-oil system. The pistons have fully-floating gudgeon pins with provision for lubrication of the piston bosses and drains of ample size which permit a steady flow of oil through the top ends and the gudgeon pins. The cylinder liners are made from the pearlitic type of cast iron and are finished by fine boring. The engine frames are monobloc castings; they are in two sections, bolted together at the centre of the engine and fitted with adjustable and removable camshaft bearings of the semi-circular seat type. Access doors, which can be seen in the illustration, are provided back and front for inspection of the connecting rods and they are sufficiently large to permit the removal of the pistons through the crankcase. The bedplate, which is of cast iron, is of the dry-sump type. It has a gradual slope to the aft end, where a drain pipe conveys the lubricating oil to a drain tank outside the engine. The crankshaft is the semi-built type with integral cast crankpins and crank-webs shrunk on to journal pieces. The cylinder covers are water-cooled and are secured to the frame by studs.

The Napier turbo-charger comprises a single-stage centrifugal air-blower directly coupled to a single-stage impulse turbine driven by the exhaust gases from the engine. The gas-turbine casing is made from a heat-resisting Meehanite, the air impeller from an aluminium-alloy forging and the turbine wheel and all the turbine parts are of heat-resisting materials. Regulation or governing of the turbo-unit is said to be unnecessary. The turbine inlet casing is provided with four entries, and four separate exhaust manifolds are arranged to conduct the exhaust gases from pairs of cylinders, thus preventing interference and giving rise to pulsations which promote scavenging. Each turbine inlet is connected to an independent group of nozzles for guiding the gases on to the turbine wheel.

Gas-Turbine-Driven Compressor.

Fig. 140, on Plate XXIX, shows a model of a gas-turbine-driven compressor built by Harland and Wolff, Limited, which was also shown by them at the exhibition. It has been ordered by the Middlesex County Council for the Mogden sewage-disposal works, and has an output of 25,000 cub. ft. of free air per minute at 7½ to 9 lb. per square inch for delivery to the digestion tanks. The cycle employed by this unit is of the two-shaft open type, with an intercooler between the low-pressure compressor and the high-pressure compressor. Reheat is employed between the high-pressure turbine and low-pressure turbine, and the exhaust from the low-pressure turbine passes a heat exchanger, from which the air for the main combustion chamber is drawn. The complete unit has been designed for industrial duty with the emphasis upon reliability and ease of maintenance. The turbines and compressors are separate units with split casings to enable the rotors and bearings to be examined easily with the minimum of dismantling; the combustion chambers are arranged with flanged joints to enable the linings to be inspected.

The low-pressure centrifugal compressor is a single-stage double-flow type with two outlets, one to the digestion tanks and the other to the inter-cooler. The high-pressure compressor is a two-stage centrifugal type with a double-flow impeller for the first stage and a single-flow impeller for the second. The compressor shafts are mounted on resilient whitemetal-lined bearings which are pressure-lubricated. The high-pressure turbine is a double-flow three-stage reaction type and is directly coupled to the high-pressure compressor by a flexible coupling. The casing is of the two-cylinder design, lagged internally. A built-up shaft and disc-type air-cooled rotor with special provision for minimising thermal expansion is used. The low-pressure turbine is a four-stage single-flow machine and is otherwise similar to the high-pressure turbine. The combustion chambers are designed to burn oil or sludge-gas, or a combination of the two in any desired proportions. The chamber volumes have been made large to ensure complete combustion of this slow-burning sludge-gas.

The intercooler is a single-pass finned-tube type with air passing over the tubes and water through them. The four-pass contra-flow heat exchanger has the exhaust from the low-pressure turbine passing through the tubes, and the air on the outside. The tube bundle is removable and the entire unit is constructed from mild steel. All the high-temperature pipework is lagged internally and provision has been made for expansion. The liquid fuel is supplied by means of a reciprocating type of electrically-driven pump and the sludge-gas is supplied from a two-stage rotary compressor. A hydraulic servo-assisted governor on the low-pressure turbine controls the supply of fuel to both combustion chambers, with arrangements for keeping the quantity of fuel to each chamber in the correct proportion, and provision is made for instantaneous change-over from oil to sludge-gas without stopping the turbine or reducing load. If the turbines overspeed, excessive temperatures are attained or a failure of the lubricating-oil supply occurs, emergency gear cuts off the fuel supply and releases the pressure air. The unit, when installed, will have the turbines, compressors, combustion chambers, intercooler and starting gear at engine-room floor level. The heat-exchanger ducting and auxiliaries will be housed in the basement.

Horizontally-Opposed Cylinder Compressor.

Another exhibit on the stand of Harland and Wolff was the Cooper Bessemer two-cylinder compressor which is illustrated in Fig. 141, Plate XXIX. The cylinders are horizontally opposed and coupled to a crankshaft at the centre; this crankshaft, which is of forged steel, is supported in whitemetal-lined bearings and counterbalanced. Compressor cylinders of varying size and stroke can be fitted for either single-stage or two-stage compression. The unit shown is arranged for use with an external drive. Compressors of this type can be built with as many as 10 cylinders if required. Pressures of up to 15,000 lb. per square inch can be dealt with and the prime-mover power range covered is from 100 h.p. to 5,000 h.p. in speeds from 250 to 514 r.p.m. The cylinders of this compressor are designed so that they can also be arranged in the same manner on the side of the crankcase of a specially-designed gas engine which has its cylinders arranged in normal V-form above the crankshaft. This is made possible by using a special arrangement of a master rod driving the compressor and scavenge pump, and slave rods for the engine pistons.

Centrifugal Pumps.

Sigmund Pumps Limited, Terminal House, Grosvenor-gardens, London, S.W.1, were displaying a wide range of centrifugal pumps. Among these was the new S.R. pump, shown in Fig. 143, Plate XXIX, on view for the first time. It has been designed for use in such services as air conditioning, boosting, circulating systems, condensate, general water supply, etc., where the installation space is limited. It is made with motors which range in horse-power from 1 to 15 and rotate at 1,450 r.p.m. or 2,900 r.p.m. The pumping unit can be obtained with suction and discharge bores from 1½ in. diameter to 5 in. diameter and a wide performance range of from 7 to 200 ft. head and 10 to 600 gallons per minute. The single shaft used carries the impeller of the pump at one end and the rotor at the other, and it is supported by a heavy ball bearing at the centre, while the pump end runs in a bush that passes through the centre of a packing gland and the other end runs in a ball bearing fitted into the stator housing. The stator and its housing are designed so that they can be easily withdrawn as a whole for inspection without disturbing the rotor or pumping unit. A fan is mounted within the motor unit at the pump end; it draws a steady flow of cooling air through the entire motor. A stream of air passes around the heavy centre bearing and is discharged in such a way that it helps to prevent any moisture from entering the bearing.

Model of a Shell Pumping Plant in Venezuela.

In Fig. 142, Plate XXIX, is shown an interesting scale model of a pumping station which was also displayed on the stand of Sigmund Pumps, Limited. It shows the layout of one of three distillation units at the Cardon refinery of the Shell Company of Venezuela, which is equipped with a variety of Sigmund horizontal and vertical pumping units. The model was made by Mr. C. A. Mills, 18, Manor-road, Ruislip, who is well known for his work in the construction of scale models for industrial and exhibition purposes.

Centralised Hydraulic Remote-Control Cabinet.

On the stand of the Automotive Products Company, Limited, of Leamington Spa, was a full-size working model of a centralised type control cabinet for power-hydraulic and manual-hydraulic control; a similar unit is shown in Fig. 144, on Plate XXIX. It is of a type which is widely employed in industry for either near or remote control of boiler dampers, for the operation of water-filtration plant sluice valves, and other similar applications. It has also been used for the control of windows in hospitals, factories, and power stations. The control cabinet houses a pump driven by an electric motor which is controlled by a metering and reversing valve mounted on the control panel. The flow of a fluid from the pump provides the source of the power for operation. The manual control is provided by the handwheel shown in the illustration, which operates either a four-cylinder type of transmitter pump or a duo-directional type of pump; this is provided for use mainly in the event of failure of the electrically-operated pump. The change-over from automatic to manual control is by a valve which is said to effect the change immediately. A number of selector valves in the form of hand levers, which can be seen in the illustration, enable the various mechanisms linked with the control to be put into circuit. The pump unit is then brought into operation and electrical indicators show—in the case of the panel exhibited—the position of window opening; another indicator lights up when the fully-open or fully-closed position is reached. A coupling valve, which can also be fitted, gives operation to two mechanisms simultaneously or otherwise.

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

(*For Description, see Page* 393.)

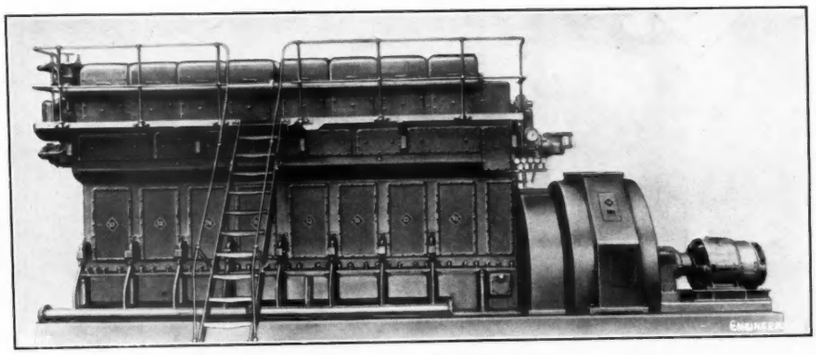


FIG. 139. 1,280-KW GENERATING SET; HARLAND AND WOLFF, LTD.

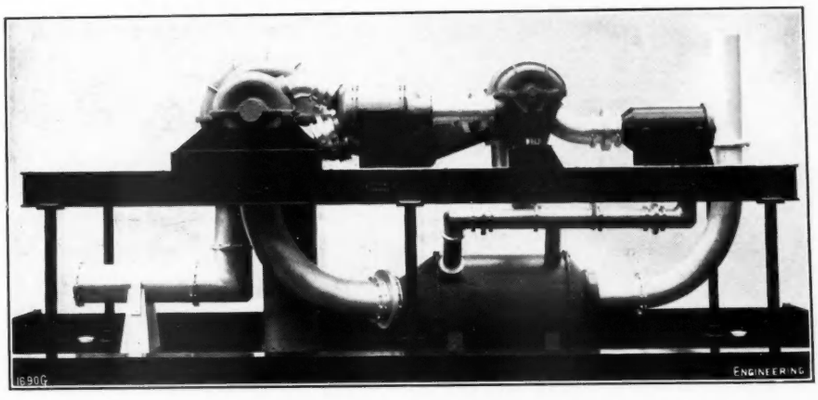


FIG. 140. MODEL OF GAS-TURBINE-DRIVEN COMPRESSOR; HARLAND AND WOLFF, LTD.

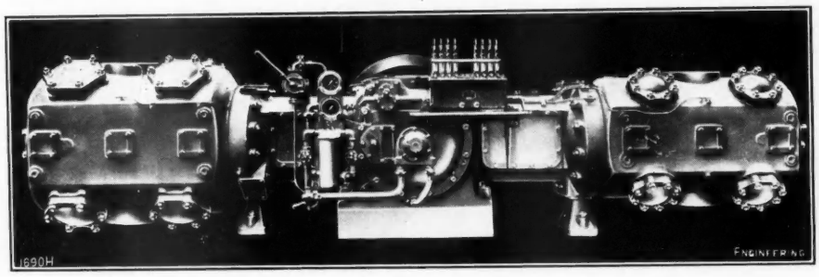


FIG. 141. TWIN-CYLINDER HORIZONTALLY-OPPOSED COMPRESSOR; HARLAND AND WOLFF, LTD.

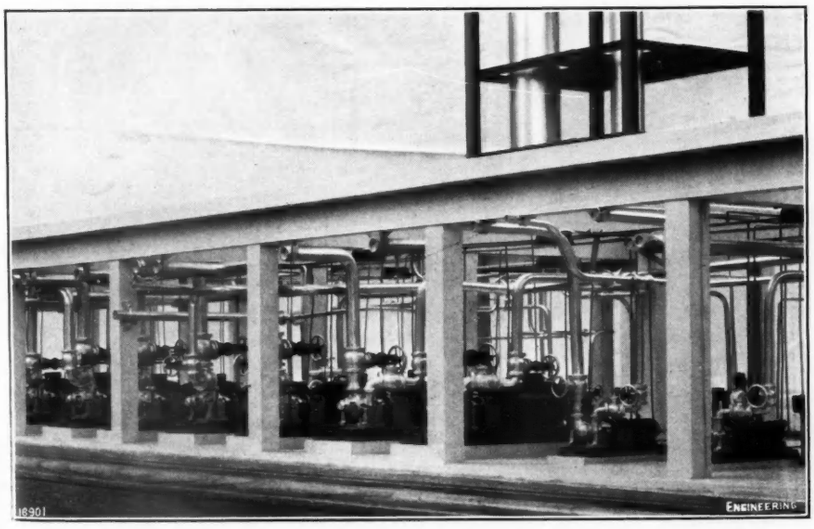


FIG. 142. MODEL OF PUMPING PLANT AT CARDON REFINERY, VENEZUELA; SIGMUND PUMPS, LTD.

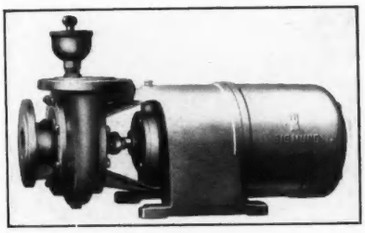


FIG. 143. CENTRIFUGAL PUMP; SIGMUND PUMPS, LTD.

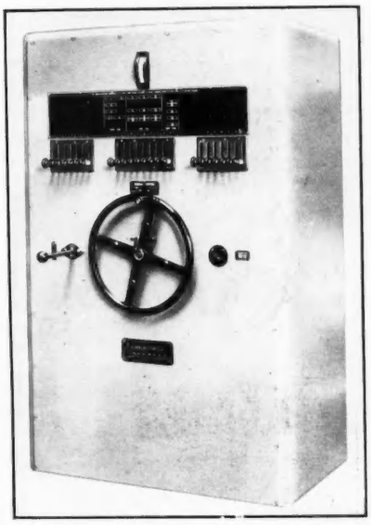


FIG. 144. HYDRAULIC REMOTE-CONTROL CABINET; AUTOMOTIVE PRODUCTS CO., LTD.

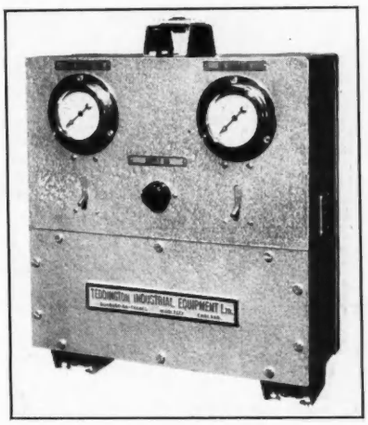


FIG. 145. ENGINE PROTECTION UNIT (ELECTRIC); TEDDINGTON INDUSTRIAL EQUIPMENT, LTD.

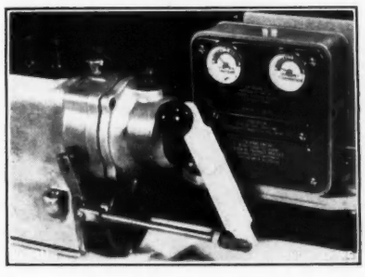


FIG. 146. ENGINE PROTECTION UNIT (MECHANICAL); TEDDINGTON INDUSTRIAL EQUIPMENT, LTD.

(*To face page* 394.)

ENGINEERING, MARINE AND WELDING EXHIBITION AT OLYMPIA.

(For Description, see Page 395.)

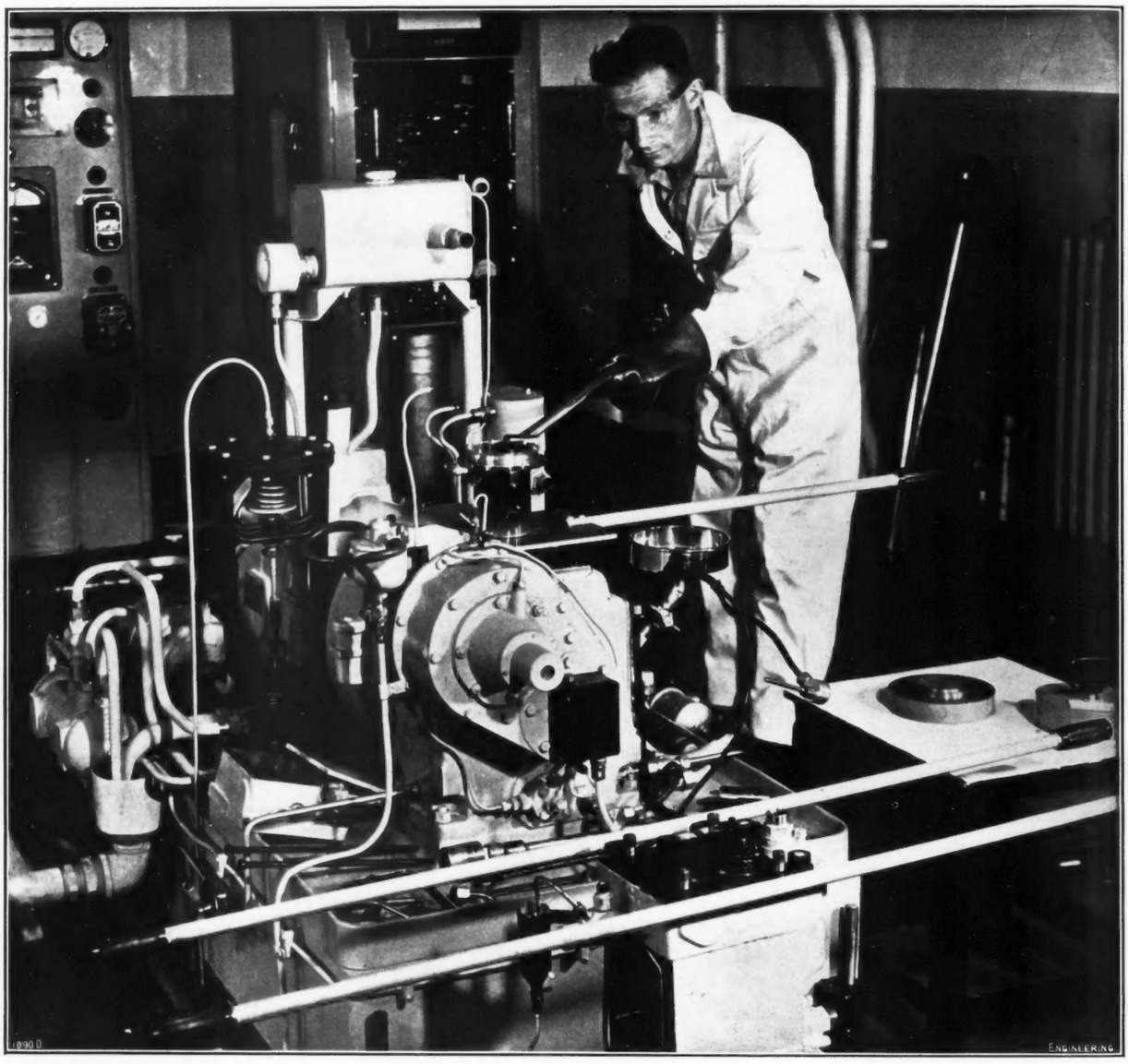


FIG. 147. MEASURING PISTON-RING WEAR; SHELL-MEX & B.P. LTD.

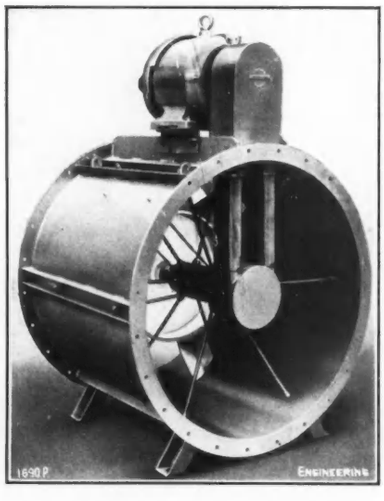


FIG. 148. AXIAL FAN WITH ROPE DRIVE; KEITH BLACKMAN, LTD.

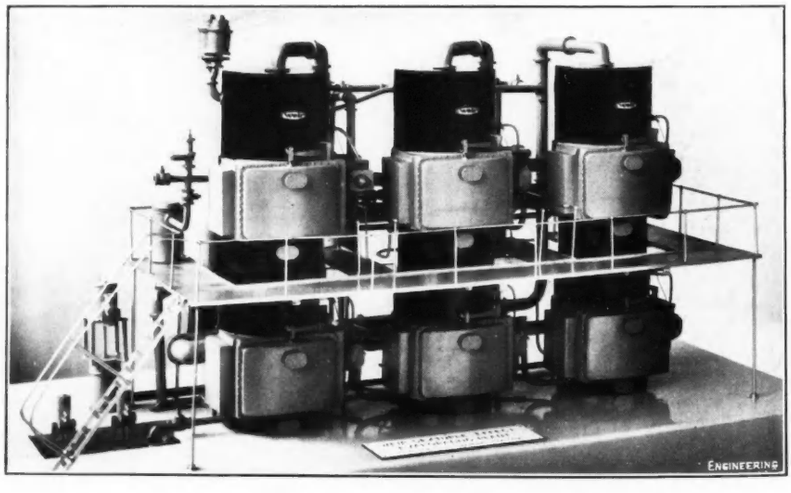


FIG. 149. MODEL OF SEXTUPLE-EFFECT EVAPORATING PLANT; G. & J. WEIR, LTD.

(To face page 395.

ENGINE-PROTECTION UNITS.

Several types of control equipment were shown by Teddington Industrial Equipment, Limited, Sunbury-on-Thames, Middlesex. Among them were two units for protecting oil engines, one operated electrically and the other mechanically. These are illustrated in Figs. 145 and 146, respectively, on Plate XXIX. Both are arranged to give protection against fall in oil pressure or rise in cooling-water temperature, and are connected to these systems. The electrically-operated unit acts through a solenoid, controlling either the throttle lever or the fuel supply. An external source of power is therefore needed. The mechanical unit acts directly on the throttle lever. A delay device is incorporated in the units to enable the engine to be started up, when, of course, there will be no oil pressure. Indicators are fitted to show the cause of failure, and remote indication can be used with the electric model.

MEASURING WEAR BY RADIOACTIVITY.

The measurement of piston-ring wear is generally a lengthy process, but a method has been developed using irradiated rings which greatly reduced the time required. Shell-Mex and B.P., Limited, Shell-Mex House, Strand, London, W.C.2, showed a complete test unit using this method. A 5-brake horse-power single-cylinder Diesel engine of standard manufacture drives a generator as a brake. The top ring of the piston has been irradiated at Harwell with the co-operation of the Atomic Energy Research Establishment. Particles worn from this ring are carried away by the oil and their radioactivity is measured. This gives a very accurate measure of the rate of wear. The illustration, Fig. 147, Plate XXX, shows the radioactive top ring being placed on the piston. The engine controls are all on the left-hand panel at the rear, while the right-hand panel carries the detector equipment. The lubricating oil from the engine is pumped to this panel and circulates through the vertical cylinder which can be seen at the bottom of it, and houses the detector and amplifier. The pulses are integrated and recorded on the moving chart, just visible at the top of the panel. Thus any variation in the rate of wear can be seen, and the effects of changing the running conditions, or of mixing additives with the oil, become apparent immediately.

AXIAL FAN WITH EXTERNAL MOTOR.

Keith Blackman, Limited, Mill Mead-road, London, N.17, were showing a variety of air-intake and exhaust fans, and in Fig. 148, Plate XXX, we illustrate their type AFX axial fan which has recently been introduced. The main feature of this unit is that the motor is mounted outside the fan duct, as can be seen in Fig. 148, and the fan is driven by a V-rope. This arrangement enables standard base-mounted motors to be used and in many cases the motor operates under cooler conditions. The V-rope drives an aluminium-alloy runner mounted centrally in a sheet-steel casing, which has steel channels welded to the outer surface between the end flanges to make a rigid structure. The fan is keyed on to one end of a shaft which is supported in two ball-bearings. A superstructure built on to the casing carries the motor. A guard fits over the motor pulley and V-rope, and when the fan is to be used for extracting gas that might be harmful to the belt-drive a removable guard is also fitted internally. Fans of this type are to be manufactured in diameters from 16 in. to 48 in. The volume range will be from 1,000 to 40,000 cub. ft. per minute, and the static pressure range from 0·1 in. to 4 in. water gauge. A similar range of fans will also be made for marine applications.

SEA-WATER DISTILLATION PLANT.

The exhibits of G. and J. Weir, Limited, Cathcart, Glasgow, S.4, consisted of a selection of large and small pumps for boiler-feed and other purposes, an air-compressor unit, and a gland-steam condenser which forms a part of the Weir closed-feed system, and, in service, is doing much to reduce humidity in ships' engine rooms. The feed pumps were mostly of the direct-acting type, and the largest model exhibited was a 6-in. by 8½-in. pump with a stroke of 18 in.; this pump has a capacity of 2,700 gallons per hour at a discharge pressure of up to 300 lb. per square inch. The smallest feed pump exhibited was a motor-driven unit of the single-throw type with a capacity of 300 gallons per hour. A direct-acting water service pump with a capacity of 9,000 gallons per hour, and a small vertical oil-feed pump with a capacity of 170 gallons per hour at up to 250 lb. per square inch, were also exhibited. The air-compressor was of the two-stage two-crank motor-driven type, with a working pressure of 450 lb. per square inch and handling up to 200 cub. ft. of air per minute.

On the same stand were some interesting models of the larger items of plant constructed by the firm. Among them was the model of a sextuple-effect evaporating and distilling plant, shown in Fig. 149, on Plate XXX. Plants of this type have been erected at Curacao and Aruba for supplying fresh water to ships calling at these ports; each is capable of distilling 300 tons of fresh water daily from the sea, when supplied with steam at 25 lb. per square inch. Somewhat similar installations, but adapted for marine use, have been fitted to several of the newer passenger vessels and tankers.

FIG. 150. TRANSFORMER-OIL FILTERING UNIT; STREAM-LINE FILTERS, LTD.

TRANSFORMER-OIL FILTERING UNIT.

The principal exhibit on the stand of Stream-Line Filters, Limited, Ingate-place, London, S.W.8, was their CN37X portable filter unit, which is illustrated in Fig. 150, herewith. It is one of their range of insulating-oil filters for cleaning oil in electrical transformers and circuit breakers, and is mounted on pneumatic tyres so that it can be towed from one sub-station to another. Two connections are provided on the outside of the pump for the oil, which is drawn from the transformer and returned to it. While in operation there is a negligible change in the level of the oil in the transformer. An electrically-driven pump draws the oil from the transformer through a chamber which is heated by an immersion heater and pumps it into the filter; this has an element which is made from a specially-prepared paper packed in layers and held under compression by spring loading. The oil is required to pass between the layers of paper, and in the process most of its impurities, such as the colloidal carbon formed in the transformer, are removed. The oil then passes to a vacuum receiver where it is subject to drying and de-aerating action. A rotary pump then extracts the clean oil and returns it to the transformer or to a storage tank. The filter element can be cleaned by reversing the flow and directing compressed air through the system, when a cock at the bottom of the filter can be opened and the sludge discharged. The filter plant is provided with a junction box and connection for coupling to the mains supply. A quick release towing connection is provided on the vehicle, together with an automatic brake, and telescopic supports are fitted at each end to enable the unit to stand firmly when disconnected from the towing appliance.

DIESEL-ELECTRIC MOBILE CRANE.

THE mobile crane illustrated on the next page, which was originally designed for use by British Railways, was made by Walker Brothers (Wigan), Limited, Pagefield Iron Works, Wigan. It is a Diesel-electric vehicle, having a power layout as shown in Fig. 1. A Gardner 75-brake horse-power engine drives a 32-kW generator and this supplies current to an electric motor which provides the drive to the rear wheels, the hoist motor and the slewing motor. The maximum road speed obtainable is about 15 m.p.h. and a gradient of 1 in 12 can be negotiated. The driver's seat is arranged so that it can be rotated, and the controls for operating the crane are placed directly behind the seat; this enables the driver to turn quickly from driving the vehicle to operating the crane. The crane can be rotated on its turntable through 360 deg. in one-third of a second, and will lift a 6-ton load at a maximum distance of 10 ft. from the centre of the turntable. A load of 8 tons can be raised at this distance if the outriggers fitted behind the cab are used to give additional stability. A number of jibs of different lengths can be provided for the crane, up to a length of 35 ft., the loads varying according to the length of jib and angle at which it is set. Fig. 2 shows the crane with the outriggers in position, while lifting a load of 8 tons. Other versions of this crane are also being made for British Railways, the paper and board industries and for overseas.

The chassis, which has a 10 in. deep by 3½ in. flange channel frame on each side, is heavily laminated with flat bar stock welded along the top face of the frames. It is cross braced in the normal manner and is designed to avoid the effects of any sudden change in the stresses imposed upon it. Flitch plates and channels, to a depth of 17 in., reinforce the bogie trunnion bracket. The engine is mounted at the front end beneath a normal type of bonnet well forward of the front axle, as can be seen in Fig. 1, and a roomy cab is mounted directly over the front axle. Behind the cab, and built integral with the chassis, is the turntable and superstructure carrying the jib. The overall length of the chassis is 19 ft. 10½ in. and it is supported at the front on two 9·00 in. by 20 in. 12-ply single tyres, and at the rear on eight 10·00 in. by 20 in., 14-ply tyres with 10-stud wheels.

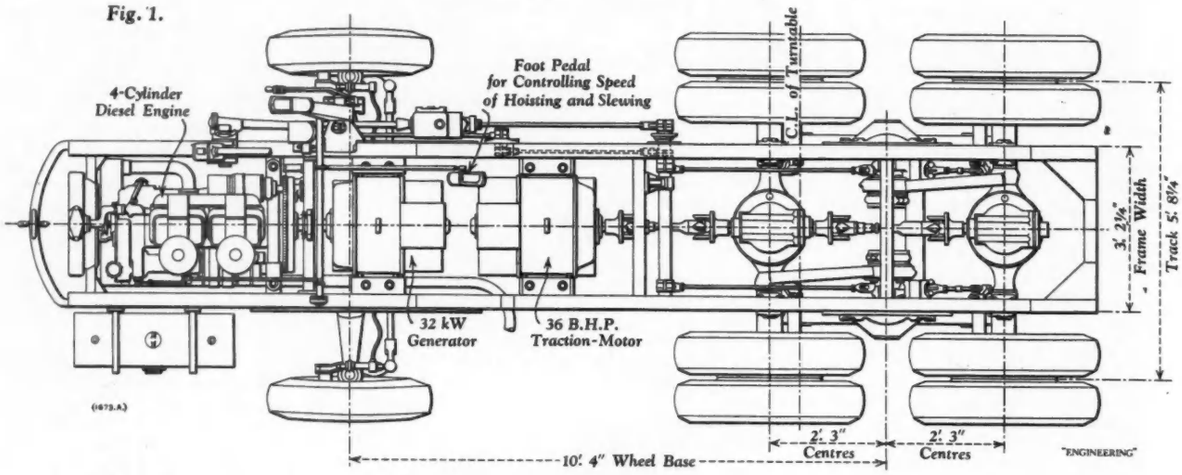
The turntable of the crane is roller mounted and its centre is slightly forward of the bogie centre line. The upper half of the turntable carries a vertical "A" frame," the apex of which forms the pivotal point of the hoisting jib; also attached to the upper part of the turntable are the counter-balance weight and the hoisting, slewing and luffing gears with their respective drives. An indicator showing the safe angle and load is mounted on the jib frame opposite the pivoting axis; this can be seen in Fig. 2. The 16½-h.p. hoist motor is controlled by a reversing-drum type of spring-return switc h situated on the right-hand side of the driver. A patented gear unit also enables the main hoisting motor to be used for derricking; this is done in such a way that the bottom block remains horizontal while the jib moves, very little power being required to carry out this operation. If the electrical drive for the derricking gear should fail, a hand-operated gear can be used to lower the jib and load. The controls for the 3½-h.p. slewing motor are placed on the left-hand side of the cab.

The Gardner Diesel engine, which provides the power, is a four-cylinder unit and is capable of developing 75 brake horse-power at 1,700 r.p.m. It gives a maximum torque of 245 lb.-ft. at 1,100 r.p.m. and is coupled directly to the 32-kW generator, as shown in Fig. 1. A pulley-wheel situated adjacent to the coupling provides a V-belt drive to an oil pump for the braking system. The generator, which is shunt wound, is of the steel-yoke pattern and has a continuous rating of 335 volts at 1,700 r.p.m. The traction motor, which is series wound, can be seen directly behind the generator in Fig. 1; it develops 36 brake horse-power at 1,500 r.p.m. It is coupled by a propeller shaft, fitted with needle bearings, to the driven axles of

DIESEL-ELECTRIC MOBILE CRANE.

WALKER BROS. (WIGAN) LTD., WIGAN.

Fig. 1.



the rear bogie, both of which are fitted with a differential gear. Rigid swing bars pivoted at their longitudinal centres and attached at each end to the axle beds, locate the two axles and allow longitudinal oscillation. Transverse movement, to a controlled extent, is permitted through the trunnion-mounted ends of the swing bars. A 4-in. diameter by ¼-in. thick tube straddles the main mounting bracket to each frame side member, and completes a very rigid structure.

The load imposed on the frame-mounting brackets is equally distributed to each axle; one axle can rise and the other fall without affecting the wheel-load distribution. Similarly, since each swing bar is independently pivoted and anchored by spherical bearings, diagonally-opposite wheels can rise without causing distortion of the vehicle frame. Driving and braking torque reactions from each pair of wheels are absorbed by torque arms coupled to the bogie cross-tube. The location of the arms—almost horizontal—makes it possible to increase the length, thus increasing the effective leverage while correspondingly reducing the end loading. The flexible joints on these torque arms are of bonded steel and rubber, eliminating the necessity for maintenance. The main bogie bearings are fully enclosed and sealed against the ingress of water and foreign matter. They comprise a 3-in. diameter hardened-steel pin mounted on needle-roller bearings spaced at 9-in. centres. Hardened-steel housings enclose the rollers and no adjustment is necessary.

Continuous-flow hydraulic brakes, which are operated by foot, operate on all six wheels and the hand brake operates on the four driven rear wheels. The hand brake is designed to allow hydraulic application of the shoes and thus ensure efficient and strong braking. The linkage is so arranged that there is no snatch in the system. The footbrake operates the hydraulic cylinders on the front axle, which are adjacent to each brake drum, there being two independent systems operating the front and rear wheels as a protection against failure.

Hydraulically-operated outriggers, which give added stability when lifting, are fitted to the chassis frame, as previously mentioned. They are for use with loads greater than 6 tons at 10 ft. radius and up to 8 tons at 10 ft. radius, and are controlled from the driver's cab by a pump and distributor valve. The arms of the outrigger are hinged at the centre and they are opened and closed by a hydraulic ram. When the arms are fully extended the hydraulic circuit is diverted to operate the jacks fitted at the ends of the arm. The stroke of the ram is sufficiently long to take up inequalities in ground contour and permit full ground clearance when retracted. Upon release of the hydraulic pressure through the driver's control the jacks return to their normal position and the outriggers fold up. Forty-five seconds are required to set up the jacks.

FIG. 2. CRANE WITH OUTRIGGERS IN POSITION.

Safety devices provide a warning against overloading, overwinding and overderricking and they can be arranged to operate buzzers, flashing lights or switch off the power automatically. Alternatively, a warning, if ignored, can be followed by cut-out. These safety devices automatically set themselves to the safe range for the conditions, slopes, etc., on which the crane is working.

OPERATING GEAR FOR WINDOWS AND VENTILATORS.—We have received from Messrs. Henry Hope & Sons, Ltd., Smethwick, Birmingham, a copy of their catalogue No. 267, entitled "Hope's Gearing," describing methods of operating ventilators and opening windows, either singly or in concert. A feature of the brochure is the lavish use of illustrations, covering power stations, industrial and office buildings, hospitals and other public institutions, etc. The half-tone illustrations are supplemented by line diagrams showing the methods of operation, which include shaft and lever gear, electrically-actuated "tension gear," cable gear, hydraulically-operated gear, and special gears to suit particular circumstances. Among these may be mentioned a quick-release fusible-link gear designed to open ventilators instantaneously in the event of fire, to clear away smoke and fumes; and a door-opening gear, operated by push-button, for use in hospital corridors, to enable patients in wheel-chairs to open and close doors from either side.

LOCOMOTIVE MAINTENANCE RECORD.—For the four weeks to June 13, the average mileage run by British Railways' steam locomotives between mechanical failures was 32,878, compared with 19,174 for the corresponding period in 1949, 20,365 in 1950, 26,319 in 1951, and 32,183 in 1952.

THE DEVELOPMENT OF LONDON AIRPORT.

Fig. 1.

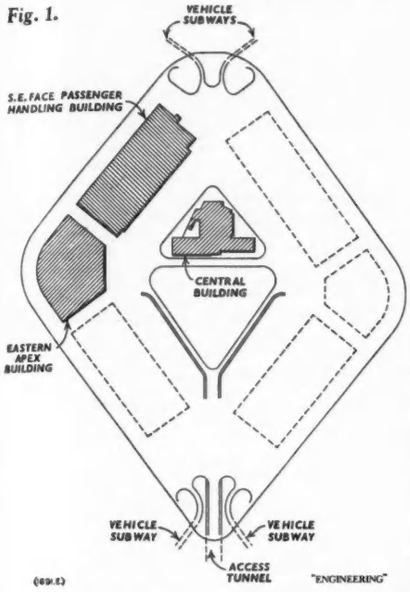


Fig. 2. PASSENGER FLOW.

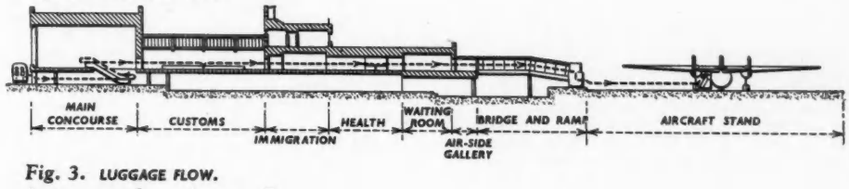
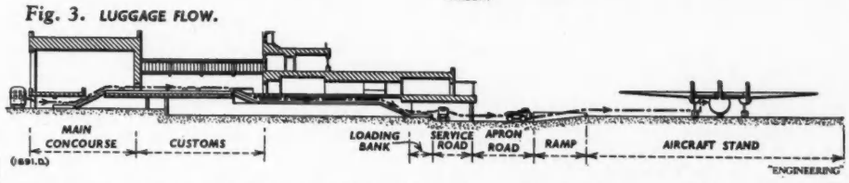


Fig. 3. LUGGAGE FLOW.



THE DEVELOPMENT OF LONDON AIRPORT.

LONDON Airport is already the busiest airport in Europe and one of the world's largest international air terminals. During the past week, the plans have been published for the development of the central terminal area of the airport at an immediate cost of 6,750,000*l*. Of this sum, roughly 1,500,000*l*. was spent on acquiring the land, 1,330,000*l*. has, or will be, spent on services and 3,500,000*l*. will be spent on the three buildings, models of which are illustrated on page 400. The airport, opened for civil aviation on January 1, 1946, at present covers 2,827 acres south of the Bath Road at a point about 15 miles west of the centre of London; it is now used by 23 international airlines and, during 1952, it handled 845,000 passengers and 2,000 tons of freight. By 1960, the number of passengers to be handled annually is expected to reach 3,500,000.

The details of the plans for the central terminal area were made public by the Rt. Hon. Alan Lennox-Boyd, M.P., Minister of Transport and Civil Aviation, on Wednesday, September 16. In the course of his remarks the Minister intimated that it was proposed to reduce the number of airports serving London from seven to three. Apart from London Airport, Gatwick and Blackbushe were to be further developed for operation; Standsted was to be maintained in reserve; and Northolt, Bovingdon and Croydon would, in due course, cease to be operated by the Ministry. The Minister defended the cost of the airport, expected to reach 26,000,000*l*. with the completion of the buildings now planned, by comparing the number of passengers to be handled with those passing through the principal ports of the United Kingdom and with the capital expenditure that had been approved for the development of those ports. He added that it was intended to make London Airport into a first-class national asset.

At present, the main elements of the airport comprise a system of runways, a temporary terminal area on the northern boundary, three maintenance areas (only two of which are as yet in use) and the central permanent terminal area which is about to be developed. The six runways are complete; arranged in three parallel pairs, they are sufficiently long and strong enough to serve any transport aircraft likely to be operated in the foreseeable future.

The permanent terminal area is to be established in a diamond-shaped space of 158 acres located in the centre of the runway system and it will form the physical, as well as operational, focus of the airport. The area will be connected with the remainder of the airport and with the Bath Road by the main access tunnel which is 2,000 ft. long and 86 ft. wide, and contains two separate 20-ft. carriageways, two independent cycle tracks and two pedestrian paths. The area is bounded by an outer taxiway which encloses, on the north-east and south-east sides of the diamond, two extensive concrete aprons providing standing room for 34 aircraft.

The present stage of the development plan provides for three buildings designed by Mr. Frederick Gibberd, F.R.I.B.A., M.T.P.I., who was appointed as architect by the then Minister of Civil Aviation in 1950. The relative location of the three buildings within the area—a principal control building, a passenger-handling building and the eastern-apex building, for crew briefing and providing amenities for the public—is shown in Fig. 1, above. All three buildings are now in the course of construction under the supervision of the director-general of works, Air Ministry; the estimated completion dates are: the control building, July, 1955; the passenger-handling building, September, 1955; and the eastern-apex building, January, 1956. In each case, parts of the buildings will be brought into use before final completion of the block. A system of subways between the various buildings will carry the heating, electricity, pneumatic and other main services; heating is to be by a high-pressure hot-water system. The responsible consulting engineers are Sir William Halcrow and Partners, Westminster; Ewbank and Partners, Grosvenor-place, S.W.1; and G. H. Buckle and Partners, Harrington-gardens, S.W.7. The principal contractors are Redpath, Brown and Company, Limited, Albion-road, Edinburgh, 7, for the steelwork, and Taylor Woodrow Construction, Limited, Ruislip-road, Southall, for the foundations and general building work. All the buildings are designed on a grid of 12 ft. with main structures of steel frames and clad with hand-made brick, stone or glass. Artificial ventilation, air conditioning and heating by radiators is provided throughout and special attention has been paid to the design of the artificial illumination.

The control building stands to the south of the centre of the inner terminal area facing the southern entrance to the main tunnel. From this position, the tower commands an all-round view of the dual parallel runway system, their approaches and the outer taxiway. All movements of aircraft using the airport, as well as of all motor vehicles within the area, will be controlled from this building, which will also contain the headquarters of the airport management, aeronautical telecommunications, the medical centre, restaurants and welfare facilities for all staff employed within the area.

The building, illustrated in Fig. 6 on page 400, is arranged on a T-shaped plan with a control tower, 122 ft. 6 in. high; the upper floors and the glazed penthouse on the roof will be used by the air-traffic control services. In plan, the tower is formed by two intersecting trapezia with staircases and a central services core between them. The arrangement of the tower walls, on varying planes to each other, is intended to minimise the interference which large flat surfaces would be likely to cause to radio-approach and landing aids.

The central services core reaches to the full height of the tower and will contain the lifts, ventilation trunking, pneumatic tubes and cable ducts. Underneath all the control rooms there will be a false floor in which all cables and tubes from the vertical services core can be run to any point within the room, thus ensuring flexibility in layout and ease of maintenance or replacement of technical equipment. The height of the approach control room is to be 15 ft. in order to accommodate an information panel (with a "tote" display) placed against the back wall in the widest part of the room and communicating directly with the vertical duct. Enclosed by glazing, the control room itself will be cantilevered out beyond the face of the tower.

The first of the passenger-handling buildings to be built is to be sited opposite the south-east terminal apron. The intended appearance of this building is indicated in Fig. 4, on page 400. Besides providing handling accommodation for passengers and their luggage, it will provide facilities for spectators' entertainment, the storage of bonded spare parts, baggage stores and workshops for minor maintenance work on aircraft.

The Continental section of the building, handling passengers for overseas routes subject to clearance through Customs, health and immigration formalities, is planned at first-floor level as a series of transverse bands, containing respectively the concourse, Customs, immigration, health and waiting rooms. Ten parallel passenger channels cut across these bands at right angles between the land side and the air side of the building; as shown in Figs. 2 and 3, each channel is served by a baggage-conveyor belt running below the first floor, except in the Customs hall where the baggage is brought up for inspection. The channels are fully reversible and are thus capable of handling inward or outward passengers. Passengers travelling on internal services are to be accommodated in a section at the southern end of the building; passengers for transit or inter-line connections and not having to pass the Customs will remain in the transit suite, with its buffet-lounge, restaurants and shops, on the air side of the Customs barrier. An air-side gallery runs the full length of the building, interconnecting all passenger channels, the transit suite and the adjacent eastern apex building. From this gallery, foot bridges and ramps lead down to the apron whence coaches will take the passengers to waiting aircraft. Advantage has been taken of the large roof areas to design a series of gardens and terraces at different levels from which spectators will have a panoramic view of the airport as a whole.

The third building, illustrated in Fig. 5, is the eastern-apex building, sited midway between the two terminal aprons and forming a link between the passenger handling building just described and a similar building to be erected on the north-east side of the diamond. This building will fulfil the following functions: the handling of aircraft operations and crews, their briefing and Customs examination, meteorological forecasting and flight planning. It will also provide accommodation for spectators, and an exhibition hall and roof gardens. Facing the public entrance will be a memorial to Alcock and Whitten-Brown, who made the first direct Atlantic crossing in a Vickers-Vimy aircraft in June, 1919.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

ELECTRICITY SUPPLY IN WINTER.—The estimated peak-period demand for electricity in Scotland in the coming winter is 156,000 kW more than the power stations can supply. This was announced in Glasgow on September 14 by Mr. Charles Murdoch, chairman of the Scottish Board for Industry, which has put out an appeal to industrial and large commercial consumers to reduce their peak demand by 10 per cent. between November 2 and January 29. This action, it is stated, would reduce the gap by 62,000 kW and the remaining gap could be closed by a 10 per cent. voltage reduction, together with the reduction of load due to low frequency.

HYDRAULIC TRANSPORT OF ANTHRACITE.—Plans for the hydraulic transport of anthracite through a 250-ft. pipeline up one of the shafts at Woodend Colliery, Armadale, have been drawn up by the production department of the Scottish Division of the National Coal Board and are to be submitted to the Board for approval of the capital expenditure. The pipes will be 8 in. in diameter and the coal will be crushed to a maximum size of 2 in. to eliminate any danger of jamming in the pipe. The coal will be pumped up at the rate of 40 tons an hour, directly to the screening and washing plant.

TRAMWAY ACTIVITIES IN GLASGOW AND DUNDEE.—Glasgow Corporation Transport Department took delivery on September 15 of the first of 24 tramway cars bought from Liverpool Corporation for 500*l.* each. The vehicles are being delivered by road in trailers. After adjustments and repainting, costing about 100*l.* each, the cars are expected to be ready for service in a few weeks. They are 17 years old, but are estimated to have a remaining life of 20 years. Dundee Corporation Transport have appointed a special subcommittee to consider a proposal to acquire secondhand or new tramway cars and to examine the possibility of new tramway routes in the city.

RICHMOND PARK—GLASGOW GREEN FOOTBRIDGE.—Work has begun on the erection in Glasgow of a prestressed concrete footbridge to span the river Clyde, between Richmond Park and Glasgow Green. The structure is expected to be completed in about 15 months. It will be 335 ft. long, and will have five equal spans. The cost is estimated at about 40,000*l.*

TESTS ON ACTION OF SEA WATER ON JUTE BAGS.—The British Jute Trade Research Association are carrying out experiments in the Tay estuary to ascertain the action of sea water on sandbags. The project is a sequel to the emergency demand made on the jute industry last winter when millions of sandbags were used in the repair of damaged seawall defences on the East Coast at the time of the flood disaster. A proportion of these bags were unproofed. While it may be many months before the experiments can be fully assessed, encouraging results in respect of certain treatments are stated to have been obtained.

S.S. "DUCHESS OF FIFE" TO BE BROKEN UP.—The 50-year-old Clyde passenger steamer Duchess of Fife made her last journey on September 15, when she was towed from the Albert Harbour, Greenock, to Port Glasgow to be broken up by Smith & Houston, Ltd. Of 329 tons gross, she was built by the Fairfield Shipbuilding & Engineering Co., Ltd.

CLEVELAND AND THE NORTHERN COUNTIES.

REFIT OF H.M.S. "MAURITIUS."—Palmers Hebburn Co., Ltd., have almost completed the refitting of the 8,000-ton cruiser Mauritius, which has been at their yard since January, 1952. The Mauritius is due to leave the Tyne about the middle of October. She was built about 13 years ago by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend.

DIESEL RAILCARS IN LAKE DISTRICT.—British Railways are to introduce lightweight Diesel railcar trains in Cumberland on the Penrith-Workington, Penrith-Carlisle, Carlisle-Whitehaven, and Carlisle-Silloth lines. The scheme, which is to cost 330,000*l.*, will come into operation in 12 months' time. Each train will normally comprise two coaches driven by two 150-h.p. underfloor engines, but eight can be coupled to form a train having a carrying capacity of 520 passengers.

CENTENARY OF WEAR SHIPBUILDERS' ASSOCIATION.—November marks the 100th anniversary of the Wear Shipbuilders' Association, believed to be one of the oldest organisations of its kind in the country. One hundred years ago the Association had 75 members, many of them small shipbuilders who went out of business when sailing vessels became obsolete. At present only eight firms are represented. In the Association's first year 152 ships, totalling 68,479 tons, were launched, while, last year, the output was 26 vessels aggregating 170,242 tons.

REORGANISATION AT WALLSEND COLLIERY.—A new shaft to be sunk at the Rising Sun Colliery, Wallsend, will be 1,350 ft. deep, and, when in operation, will result in the colliery's output being raised from 2,000 tons to 3,000 tons daily. The number of miners will be increased from 1,450 to 1,800. The shaft will be 22 ft. in diameter and will draw coal from three seams. The two existing shafts will later be used for ventilation purposes only.

TRAFFIC ON THE RIVER TEES.—The Tees Conservancy Commissioners report that, during August, 336 ships aggregating 376,070 net tons had been dealt with, an increase of 39 vessels and 32,463 tons on last year's totals. During July, exports from the river amounted to 134,846 tons, a decrease of 4,001 tons on July last year. This was due to reduced foreign shipments of creosote and sulphate of ammonia. Imports, at 488,734 tons, were the highest on record, exceeding the previous best figures, in August last year, by 81,270 tons.

LANCASHIRE AND SOUTH YORKSHIRE.

THE NEED FOR SCRAP.—A new drive for scrap has been organised by the Iron and Steel Federation in co-operation with the National Federation of Scrap Iron, Steel and Metal Merchants. The aim is to collect all available metal scrap from farms and homes, as well as factories, in co-operation with various cleansing departments of municipal councils The present need is the greater now that the increased production of steel and the completion of additional melting furnaces are requiring larger supplies of melting materials, while imports of scrap have been declining.

TRADE WITH ARGENTINA.—The decision of the Argentine Government to allow imports of steel for essential purposes is gratifying to Sheffield manufacturers, who have decided to exploit new markets in Argentina. Formerly the Argentine was a very good customer of Sheffield firms in steel and various products of steel, including agricultural tools and cutlery, and also in silverware.

COAL PRICES SCHEME.—The National Coal Board have formulated a scheme under which the price of coal for industry would remain unchanged, irrespective of delivery distance. Mr. R. J. Moffat, deputy director of marketing, has explained that it is an attempt to produce an orderly system of pricing coal so that consumers would continue to pay the same delivered price if, for any reason, the Board were compelled to supply it from a more distant pit.

NEW COLLEGE OF TECHNOLOGY.—Loan sanction has been given by the Ministry of Education for Sheffield's new College of Commerce and Technology, estimated to cost more than 1*l.* million. The first stage to be constructed will be the workshops for building and engineering students. Adjoining these will be an eight-storey block of science and metallurgical laboratories, drawing and class rooms. Accommodation will be provided for 10,000 students. The main building will be eleven storeys high.

THE MIDLANDS.

MODEL ENGINE ON EXHIBITION.—A scale-model table engine, which won the premier award in its class at the recent Model Engineering Exhibition in London, has been placed in the Museum of Science and Industry, Birmingham, on indefinite loan. The model was made by two amateurs, Mr. A. J. Kent and Mr. F. H. Tapper, to a scale of 1½ in. to 1 ft., and is of a Napier table steam engine of 1851. It has been made from the original working drawings.

RURAL ELECTRICITY.—Alderman W. S. Lewis, chairman of the Midlands Electricity Board, announced at a meeting of the Midlands Area Electricity Consultative Council, held in Cheltenham on September 14, an increase of 62,500*l.* in the expenditure of the Board on rural electrification during the next six months. Alderman Lewis admitted that this was not a large sum, considering that the Board had been spending 500,000*l.* on rural development during the last five years, but said that it was the Board's policy to accelerate its rural development programme.

DUDLEY AREA PRODUCTIVITY COMMITTEE.—Following an inaugural meeting convened by the Midland Regional Board for Industry at Dudley, on July 21, a productivity committee has been formed for the area, which includes the industrial towns of Dudley, Tipton, Brierley Hill and Stourbridge. The chairman of the new committee is Mr. H. C. Davies, assistant general manager, Midland section, Richard Thomas and Baldwins, Ltd. Representatives of management, trades unions, and technical colleges have been appointed as members of the committee.

THE LATE MR. R. W. ORCHARD.—The death has been announced, at the age of 57, of Mr. R. W. Orchard, deputy marketing director of the West Midlands Division of the National Coal Board. Mr. Orchard, who spent his working life in the coal industry, joined the West Midlands Division of the Board as secretary on its foundation in 1946, and had only been appointed deputy marketing director a fortnight ago.

PUBLIC SCHOOLS AND INDUSTRY.—For three days last week, 16 careers masters from public schools in England toured factories in and around Leicester as part of a five-day convention planned to encourage public-school boys to enter industry. The representatives at the convention, which was arranged by the Public School Appointments Bureau and the Brush Group, visited the British United Machinery Co., Ltd., Leicester, the Rootes Group, Coventry, and the Brush Electrical Engineering Co., Ltd., Loughborough. Mr. Hugh Lyon, director of the Public Schools Appointments Bureau, in his speech of welcome to the convention delegates at the University College, Leicester, said that industry and commerce needed a much larger proportion of the abler type of public-school boy than they were getting at the present time.

SOUTH-WEST ENGLAND AND SOUTH WALES.

NEW BRIDGE AT CONWAY.—A new 450,000*l.* bridge is to be built at Conway to replace the one-way suspension bridge constructed by Telford 126 years ago, which is too narrow for modern needs and is considered unsafe. It will be built alongside the existing bridge. Until more funds are available, the bridge will be only half its eventual width, but, even so, it will have a 22-ft. carriageway, sufficient to carry two lanes of traffic, with two 5-ft. pathways on each side. The new bridge will be of steel and will have an arch of 111-ft. span. Telford's bridge was condemned 19 years ago and a new bridge, to cost 100,000*l.* was approved 17 years ago. Recently, the old bridge sagged so badly on one side that traffic was restricted to the other side. Heavy traffic has had to make a six-mile detour and, in summer, there have been strings of traffic on both sides of the bridge stretching for from three to four miles.

DEVELOPMENT AT A RHONDDA COLLIERY.—Plans for a 6,000,000*l.* scheme for the reorganisation and development of the Cwm Colliery, Rhoadda, have been issued during the past week. The colliery is scheduled to come into operation in 1958 and will employ 3,000 men when in full activity. It will have an output of 5,500 tons of saleable coal per day.

CARDIFF WATER SUPPLIES.—To help to meet Cardiff's growing needs for water, old wells at Ely, disused since 1921, are to be brought back into service. Dr. R. C. Hoather, of the Counties Public Health Laboratories, London, who carried out an investigation on behalf of the city waterworks department, reported that the wells could provide a supply of good-quality water. The city water engineer, Mr. George W. Cover, told his committee that, after taking into consideration all sources of supply, there was still a deficiency of 1,300,000 gallons daily. The wells, he said, seemed suitable to provide about 1,000,000 gallons a day. The daily consumption, this year, was 14,365,000 gallons against 12,225,000 gallons in 1949.

PREVENTION OF RIVER POLLUTION.—Appreciation of the co-operation of industries in Glamorgan in dealing with river pollution was voiced by Alderman P. J. Smith, chairman of the Glamorgan River Board, during the annual inspection of the River Rhymney. At Windsor Colliery, Senghenydd, the party inspected the new pollution-prevention works.

POTENTIAL DEVELOPMENTS AT CARDIFF.—The Cardiff Port Development Association, an organisation set up to foster the trade of the docks, which has been badly hit by the decline in the coal-export trade, are to show a party of shipowners and industrialists the resources of the port. The party will stay for three days in the city and will be conducted over the local works of Guest, Keen and Nettlefolds, Ltd., the steel plant of the Guest Keen Baldwins Iron and Steel Company, and on tours of the docks, and ship-repairing yards.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Bournemouth Branch:* Monday, September 28, 8.15 p.m., The Grand Hotel, Bournemouth. "Diagnosis of Faults in Fluorescent Lighting," by Mr. Mitchell. *South London Branch:* Thursday, October 1, 8 p.m., Café Royal, North End, Croydon. "Electrical Heat Treatment" (film). *Liverpool Branch:* Friday, October 2, 7.30 p.m., Liverpool Engineering Society, 9, The Temple, Dale-street, Liverpool, 2. "B.S.S. 7: 1953. Rubber and Plastic Cables," by Mr. J. R. Cox.

INCORPORATED PLANT ENGINEERS.—*Yorkshire Branch:* Monday, September 28, 7.30 p.m., The University, Leeds, "Prestressed Concrete," by Dr. R. H. Evans. *London Branch:* Tuesday, October 6, 7 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Patterns, Castings and Foundry Works," by Mr. Barnet Levy. *Southampton Branch:* Wednesday, October 7, 7.30 p.m., Polygon Hotel, Southampton. "Oxygen in Industry" (with films), by Mr. E. Ryalls. *North-East Branch:* Thursday, October 8, 7 p.m., Roadway House, Oxford-street, Newcastle-upon-Tyne. "The Use of Paint in Factories," by Mr. P. J. Gay.

IRON AND STEEL INSTITUTE.—Wednesday, September 30, to Wednesday, October 7, Special Meeting in the Netherlands. See page 111, *ante*.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section:* Wednesday, September 30, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "The Impact of Communication Theory on Television," by Dr. D. A. Bell. *North-Western Section:* Thursday, October 1, 7.15 p.m., College of Technology, Manchester. "Parasitic Oscillations in Radio and Electronic Equipment," by Mr. H. Whalley.

INSTITUTE OF PACKAGING.—*Yorkshire Branch:* Wednesday, September 30, 6.30 p.m. for 7 p.m., Metropole Hotel, King-street, Leeds, 1, "Packaging at Rowntree and Company, Limited," by Mr. B. G. Brooks. *Southern Branch:* Thursday, October 1, 6 p.m., Waldorf Hotel, Aldwych, W.C.2. "Raising Packaging Efficiency in Small Firms," by Mr. E. D. S. Baker.

INSTITUTION OF PRODUCTION ENGINEERS.—*Shrewsbury Section:* Wednesday, September 30, 7.30 p.m., Shrewsbury Technical College, "The Engineer's Part in the Production of Pottery" (with film), by Mr. J. Robinson. *Reading Section:* Thursday, October 1, 7.30 p.m., The Great Western Hotel, Reading, Film and Discussion, "Forgings (High Duty Alloys)." *Lincoln Section:* Thursday, October 1, 7.30 p.m., Ruston Club, Unity-square, Lincoln. "Men and Machines," by Mr. J. E. Hall. *Peterborough Sub-Section:* Tuesday, October 6, 7.30 p.m., The Dujon Ballroom, Market Place, Peterborough. "Planning for Production," by Mr. A. P. Peat. *Nottingham Section:* Wednesday, October 7, 7 p.m., Victoria Station Hotel, Nottingham. "Making a Mark," (with slides and film), by Mr. A. Throp. *Wolverhampton Section:* Wednesday, October 7, 7.15 p.m., Technical College, Wolverhampton. "Distribution of Goods in the Export Markets of the World," by Mr. H. W. Hunt.

INSTITUTION OF MECHANICAL ENGINEERS.—*Southern Branch:* Wednesday, September 30, 7 p.m., Brighton Technical College. "The Railways and Coal," by Mr. R. G. Jarvis. *North-Eastern Branch:* Monday, October 5, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Industrial Applications of Hydraulic Servos," by Mr. T. Brading and Mr. G. Parks. *Institution:* Tuesday, October 6, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Annual General Meeting of the Automobile Division and Chairman's Address. *North-Western Branch:* Thursday, October 8, 6.45 p.m., Engineers' Club, Albert-square, Manchester. "Design and Operation of Dunston 'B' Generating Station," by Mr. A. Howell and Mr. J. B. Jackson. *Scottish Branch:* Thursday, October 8, 7.30 p.m., Royal Technical College, George-street, Glasgow. Joint meeting with the INSTITUTION OF MARINE ENGINEERS; and Friday, October 9, 6.30 p.m., North British Station Hotel, Princes-street, Edinburgh. "Scale Formation in Sea Water Distilling Plants and its Prevention," by Mr. Harold Hillier. *Western Branch:* Thursday, October 8, 7 p.m., Royal Fort, Bristol. "The B.R.M.," by Mr. Raymond Mays.

INSTITUTION OF ELECTRICAL ENGINEERS.—*East Midland Centre:* Thursday, October 1, 7.30 p.m., Masonic Hall, Pinchbeck-street, Spalding. "Overhead Transmission," by Mr. W. H. Grimmett and Mr. R. F. Proctor. (Discussion.) *North Staffordshire Sub-Centre:* Friday, October 2, 7 p.m., Duncan Hall, Stone. Chairman's Address, by Col. C. E. Calveley. *Mersey and North Wales Centre:* Monday, October 5, 6.30 p.m., Liverpool Royal Institution. Chairman's Address, by Mr. T. Coates. *North-Eastern Radio and Measurements Group:* Monday, October 5, 6.15 p.m., King's College, Newcastle-upon-Tyne. Chairman's Address, by Mr. F. H. Birch. *South Midland Centre:* Monday, October 5, 6 p.m., Grand Hotel, Birmingham. Chairman's Address, by Mr. H. J. Gibson. Annual General Meeting and Conversazione. *Maidstone District:* Monday, October 5, 7.30 p.m. Wig and Gown Hotel Maidstone. "Fluorescent Discharge-Tube Circuits," by Mr. J. Cates. *East Midland Centre:* Tuesday, October 6, 7 p.m., Loughborough College. Chairman's Address, by Mr. C. D. Wilkinson. *North Midland Centre:* Tuesday, October 6, 6.30 p.m., B.E.A., 1, Whitehall-road, Leeds. Chairman's Address, by Mr. G. Caton. *North-Western Centre:* Tuesday, October 6, 6.30 p.m., Engineers' Club, Albert-street, Manchester. Chairman's Address, by Mr. H. West. *South-East Scotland Sub-Centre:* Tuesday, October 6, 7 p.m., Heriot-Watt College, Edinburgh. Chairman's Address, by Mr. H. V. Henniker. *Rugby Sub-Centre:* Tuesday, October 6, 6.30 p.m., College of Technology and Arts. Chairman's Address, by Mr. A. Draper. *Tees-side Sub-Centre:* Wednesday, October 7, 6.30 p.m., Technical Institute, Cleveland. Chairman's Address, by Mr. G. Richards. *North Scotland Sub-Centre:* Wednesday, October 7, 8 p.m., Caledonian Hotel, Aberdeen. Chairman's Address, by Mr. R. S. Goddard. *South-West Scotland Sub-Centre:* Wednesday, October 7, 7 p.m., Institution of Engineers and Shipbuilders. Chairman's Address, by Professor F. M. Bruce. *Southern Centre:* Wednesday, October 7, 6.30 p.m., Municipal College, Portsmouth. Chairman's Address, by Cdr. (L) C. V. Robinson. *Institution:* Thursday, October 8, 5.30 p.m. Inaugural Address by the President, Mr. H. Bishop. *North Scotland Sub-Centre:* Thursday, October 8, 7 p.m., Royal Hotel, Dundee. Chairman's Address, by Mr. R. S. Goddard. *West Wales Sub-Centre:* Thursday, October 8, 6 p.m., Central Public Library, Swansea. Chairman's Address, by Mr. E. W. Cooper.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*Western Centre:* Thursday, October 1, 7.30 p.m., The Grand Hotel, Bristol. "Thin Wall Bearings," by Mr. P. Holligan. *Scottish Centre:* Monday, October 5, 7.30 p.m., at the Institution of Engineers and Shipbuilders, Glasgow. "The Use and Abuse of Fuels," by Mr. W. E. P. Johnson. *North-West Centre:* Tuesday, October 6, 7.30 p.m., Victoria-station Hotel, Preston. "Hydraulic Transmission," by Mr. J. Houghton. *Eastern Centre:* Tuesday, October 6, 7 p.m., Lion Hotel, Cambridge. "Electrical Equipment of Heavy Commercial Vehicles," by Mr. W. A. Bevis. *London:* Wednesday, October 7, 6.30 p.m., Royal Society of Arts, John Adam-street, W.C.2. Eighth Annual General Meeting, followed by "Transport in South Africa" (with films), by Mr. T. F. Turton. *South Wales Group:* Friday, October 9, 7 p.m., B.O.C. Works, Birchgroveon, Caerphilly-road, Cardiff. "Welding Methods" (demonstration).

INSTITUTE OF WORKS MANAGERS.—*London Branch:* Friday, October 2, 7 p.m., Waldorf Hotel, W.C.2. Annual General Meeting and Film Show.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, October 2, 6.45 p.m., Engineers' Club, Albert-square, Manchester. President's Inaugural Address, by Dr. H. Wright Baker.

INSTITUTE OF MARINE ENGINEERS.—Monday, October 5, 6.30 p.m., 85, The Minories, E.C.3. "Shipbuilding," by Mr. G. Ridley Watson.

INSTITUTION of CHEMICAL ENGINEERING.—*Institution:* Tuesday, October 6, 5.30 p.m., Geographical Society, Burlington House, W.1. Five papers on "Liquid-Liquid Extraction," by Mr. H. R. C. Pratt and others. *North-Western Branch:* Saturday, October 10, 3.0 p.m., Manchester. Joint meeting with CHEMICAL ENGINEERING GROUP. The George E. Davis Memorial Lecture, by Mr. Norman Swindin.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, October 6, 6.30 p.m., 30, Elmbank-crescent, Glasgow. Presidential Address, by Sir William Wallace.

TELEVISION SOCIETY.—Friday, October 9, 7 p.m., Cinematograph Exhibitors' Association, 164, Shaftesbury-avenue, W.C.2. "Recording Television Programmes," by C. B. B. Wood.

CONTRACTS.

E.M.I. SALES AND SERVICE, LTD., Hayes, Middlesex, have received orders from the British Broadcasting Corporation for tape recorders and associated equipment to a value exceeding 100,000*l*. The models supplied range from large studio recorders, including transportable versions, to the latest-type lightweight portable battery-operated recorders now in use by outside commentators.

THE CEMENTATION CO., LTD., Bentley Works, Doncaster, have received a contract from the National Coal Board for the sinking of a shaft at the Rising Sun Colliery, Wallsend-on-Tyne. The firm is carrying out a similar task, which is expected to be completed early next year, at the Bates Pit, Blyth.

LEYLAND MOTORS, LTD., Leyland, Lancashire, have received orders valued at 250,000*l*. for 85 underfloor-engined omnibuses from the Consolidated Near East Co. Ltd., Haifa, Israel. The vehicles are to be Royal Tiger models and the bodies will be made in Israel.

PERSONAL.

H.R.H. THE DUKE OF EDINBURGH has consented to be an honorary member of the Engineering Institute of Canada, 2050 Mansfield-street, Montreal, Canada.

MR. FREDERICK GRANT, M.C., Q.C., has been appointed independent chairman of the executive committee of the British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.1, in succession to the late SIR ANDREW DUNCAN.

MR. G. R. EDWARDS, C.B.E., B.Sc., F.R.Ae.S., A.M.I. Struct.E., has been appointed managing director of the Aircraft Division of Vickers-Armstrongs Ltd., Vickers House, Broadway, London, S.W.1. This Division comprises the Weybridge and Supermarine Works. MR. T. GAMMON, O.B.E., M.I.Mech.E., has been made general manager of the Division. The firm also announce changes which are to take place in the Engineering Division on December 1. MR. W. D. OPHER, M.I.Mech.E., is to be general manager of the Elswick, Scotswood, Wakefield and Chertsey works, and MR. J. R. KELLY, general manager of the Crayford and Dartford works and in charge of the Whitehead Torpedo Works, in place of MR. W. D. OPHER.

DR. W. P. JONES has been appointed superintendent of the Aerodynamics Division of the National Physical Laboratory, Teddington, Middlesex, in succession to MR. ARTHUR FAGE, C.B.E., F.R.Ae.S., F.R.S., who retired earlier this year after 41 years of service with the Division.

MR. HAROLD DREW, A.C.G.I., B.Sc.(Eng.)(Lond.), M.I.Mech.E., who, as stated on page 303, *ante*, has been appointed assistant chief engineer of General Motors overseas operations, with headquarters in Detroit, U.S.A., resigned his seat on the board of Vauxhall Motors Ltd., Luton, Bedfordshire, on September 16. On that day MR. MAURICE PLATT, M.Eng. (Sheffield), M.I.Mech.E., Vauxhall Motors' new chief engineer, was elected to the board.

MR. L. E. MOLD, who has been a director of C. A. Parsons & Co. Ltd., Heaton Works, Newcastle-upon-Tyne, 6, for the past 15 years, has resigned from the board owing to ill health.

CAPTAIN (E) C. C. CLARK, O.B.E., D.Sc., R.A.N., has been promoted Rear Admiral (E) as from September 15, and appointed third naval member of the Commonwealth Naval Board and Chief of Construction, in succession to Engineer Rear-Admiral J. W. Wishart, C.B.E., R.A.N., who was placed on the retired list on that date.

MR. K. P. WOOD, M.A.(Cantab.), who, as stated on page 143, *ante*, resigned from the board of James Beresford & Son Ltd., on July 22, has now started his own business at 71, Temple-row, Birmingham, 2. (Telephone: Midland 0830.) His activities include representation, in the Midlands, of EDWARD HOLMES AND CO. (1931) LTD., and the K.S.B. MANUFACTURING CO. LTD.

PROFESSOR DENIS BROWNE, of the University of Sheffield, has been appointed chairman of the Sheffield Employment Committee in succession to SIR BASIL GIBSON.

MR. J. G. CHARLTON, manager of Shilbottle Colliery, Northumberland, has been appointed assistant planning engineer for the No. 1 area of the Northern (Northumberland and Cumberland) Division of the National Coal Board.

MR. B. G. J. CLARKE, B.Com.Sc., for some years past a member of the staff of the Society of Motor Manufacturers and Traders, 148, Piccadilly, London, W.1, has been appointed to succeed MR. A. W. HAMILTON BROWN as representative of the Society in New Zealand and the Far East. Mr. Brown has become managing director of the Standard Motor Company in New Zealand.

MR. W. L. BAGSHAW, previously assistant secretary of the Union-Castle Mail Steamship Co., Ltd., 3, Fenchurch-street, London, E.C.3, has been appointed secretary, as from September 15, in succession to MR. R. J. BLOXAM, F.C.I.S., now an assistant general manager. MR. C. R. MELVILLE has also been appointed an assistant general manager of the company.

TUBE INVESTMENTS LTD., The Adelphi, London, W.C.2, have reached agreement, subject to the completion of formalities, for the acquisition of W. H. A. ROBERTSON AND CO. LTD., Bedford. As is the case with the other subsidiary companies of Tube Investments Ltd., W. H. A. Robertson & Co. will continue to operate as a separate entity.

A new company, PILGRIM MOBILE UNITS LTD., Ringwood, Hampshire, has been formed to deal with mobile trailer units for use in industry. The chairman is MAJOR J. V. PHIPPS, M.A., and the managing director, MR. D. R. HOBSON, O.B.E. The new firm's London office is at 176, Piccadilly, W.1.

PROADD (ENGLAND) LTD., have removed to 76, Victoria-street, London, S.W.1. (Telephone: TATe Gallery 3311.)

DEVELOPMENT OF LONDON AIRPORT.

(For Description, see Page 397.)

FIG. 4. PASSENGER-HANDLING BUILDING.

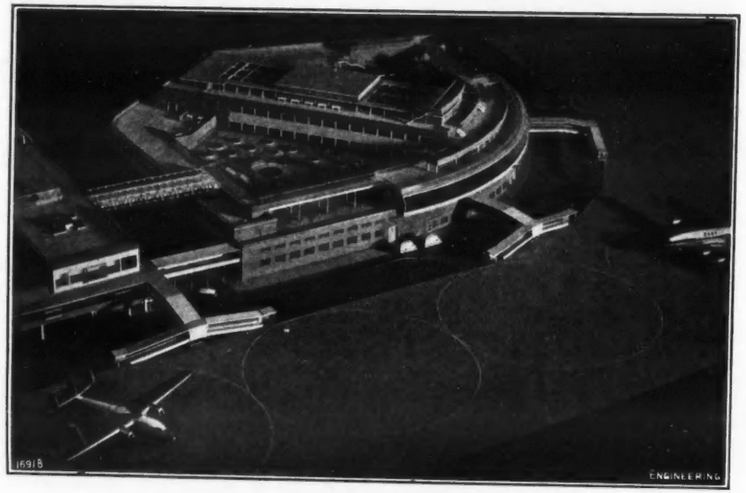


FIG. 5. EASTERN APEX BUILDING.

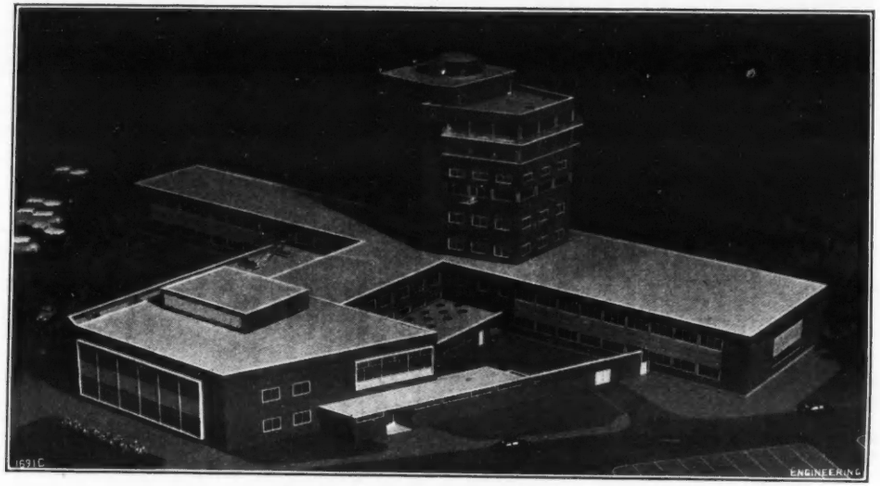


FIG. 6. AIRPORT CONTROL BUILDING.

ENGINEERING

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Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, SEPTEMBER 25, 1953.

VOL. 176. No. 4574.

THE ENGINEER AS ADMINISTRATOR.

THE role that the engineer should play in the great drama of human endeavour, and the course of training he should follow to enable him to perform that role satisfactorily, are two problems which are often discussed with animation; although it must be admitted that so far not much in the way of a definite solution to them has emerged. A further correlated question, which still awaits a reply, is to what extent engineers, besides contributing technical knowledge to the national economy, should be admitted to the ranks of that higher hierarchy, who may be conveniently described as administrators. This is something of a sore point, especially among engineers themselves, since they argue that while the value of their contribution to industrial practice is not altogether unrecognised, chance, and sometimes design too, often debar them from their share of the glittering prizes which are increasingly the reward of the lawyer, the accountant and what is termed—perhaps a little irreverently—the arts man. We may include ourselves among the holders of this view; and certainly plenty of evidence is available to support it.

The argument is not, in fact, one which should be lightly dismissed. Since if we are to progress at a rate which, it is agreed, is essential to our existence as a nation, means must be found to increase the efficiency of our man-power—especially that part of it which is capable of profiting by advanced education and will thereafter prove worthy of assuming leadership. This point may be illustrated by referring to some remarks made by Sir Harold Hartley in an address he delivered before the Institution of Chemical Engineers at the beginning of the present month. Dealing with a report in which it was stated that the United States was turning out qualified chemical engineers at the rate of some 3,000 a year, compared with the 200 that were being produced in this country, he rightly emphasised the vital part that this branch of engineering is destined to play in the future. This being so, it was necessary, he said, for better educational facilities to be made available and that more financial support for research should be forthcoming, both from the Government and from industry. As it was, many of the important chemical discoveries for which we had been responsible were being developed and exploited commercially in the United States. This was not entirely due to that country's vast home market or to her superior natural resources, but to other reasons among which we suspect Sir Harold would include greater enterprise. This failure on our part to apply basic knowledge has often been pointed out previously, but truth is not diluted by repetition.

The exploitation of the knowledge we possess, or can acquire, is, however, essential in many fields other than that of chemical engineering; and, as in that field, advances must depend upon the training of that part of our man-power which is capable of profiting by higher education, not to speak of the need to ensure that the best use is subsequently made of those thus trained. As regards that subsequent use, it has been pointed out in a recent article in *The Times* that while British scientists and engineers are good at fundamental research and invention, and are improving in production and productivity, they are "deficient in application and in begetting new products." These middle regions of activity, where our efforts are weakest, are broadly, says the writer, those of applied research. The result is that only a meagre proportion of our annual exports consists of products which have been developed since the war. While, of course, it is satisfactory that we continue to find markets for well-tried goods, it is equally essential to produce new designs, if only to meet new needs.

To overcome this hiatus in our efforts the writer considers that the volume of applied research must be increased by the provision of more money on a generous scale and that this research must be directed to clearly defined practical objectives. He makes the further interesting suggestion that if this policy is to be fully implemented more of the administrators and managers concerned should have engineering and scientific backgrounds, a suggestion which, as we have already hinted, will receive much support in engineering circles. To provide these technical administrators, the aid of the schools must be enlisted to persuade "the brightest boys" to take up scientific work and to eradicate the notion that those "doing" science and engineering will find themselves in a rut from which there is no escape. We need hardly say that we do not subscribe to the view implied in this statement that science and engineering are at present the refuge of the "less bright," but there is no reason why the admission of more of those in this category to our ranks should not be encouraged.

Some support is given to this opinion in a paper on "Training Graduate Engineers for a Professional Career," which has been written by Mr. J. Gammell, of the Allis-Chalmers Manufacturing Company, and is published in the September issue of *Electrical Engineering*. Mr. Gammell gives figures to show that only 3 per cent. of the students enrolling at American universities in 1952 were allowed (*sic*) to take courses in the fine arts, law or political science; and that by far the heaviest enrolment was in engineering. He considers the result must be that engineers will "be forced into management because they are the ones with the knowledge to solve more of the problems that beset industry than any other group"; but, curiously enough, far from regarding this as an advantage, he displays a distinct lack of enthusiasm at the

FIG. 6. AIRPORT CONTROL BUILDING.

FIG. 5. EASTERN APEX BUILDING.

prospect. To fit these young men for management, he says, not only will they have to be better trained technically, but they will have to learn "new skills—skills in inspirational leadership, skills in meeting and influencing people, skills in written and spoken communications, as well as a knowledge of law, finance, accounting and so forth—all originally alien to them."

Mr. Gammell seems to think it will not be easy to impart this extra knowledge, partly at least we gather, because the technical colleges are not providing the correct raw material. In fact, he quotes, apparently with approval, a remark of Dean R. E. Doherty, of the Carnegie Institute, to the effect that when engineers come out of college they are "mentally clumsy, relatively narrow in interest and perspective and awkward in writing and speech" besides being "practically incapable of analysing problems or situations in terms of general principles." As a result, they tend to "remain in the comparative isolation of technology," so that industry has to step in and "adapt the raw recruit to practical usefulness." Mr. Gammell also quotes, again with apparent approval, a remark of Dr. R. W. Walker, Associate Professor of Psychology at Cleveland College, to the effect that, compared with salesmen, engineers are interested in logic as opposed to feelings and believe that people can be persuaded "by means of logic better than in any other way." "Engineers," the same authority adds, "need to learn a lesson in humility. They need to grant validity to another person's point of view. Simply because they are oriented towards numbers does not mean that other people who are not number-oriented have nothing to offer our world." This may, of course, be true, but surely engineers might also be sometimes justified in complaining that administrators and accountants do not always "grant validity to another person's point of view." In fact, it is because they so often fail to do this that so many complaints are made. Further, Professor P. F. Drucker, of New York University, is quoted as saying that "professional employees do not fit into the administrative process and the administrative process does not fit them" . . . "These people" [the engineers], he goes on, "want perfection, they don't care a rap how much it costs or whether anyone else wants perfection any way"—an attitude which is curiously different from that so often quoted with complacency that an engineer is a person who can do for one dollar what any fool can do for two.

The position therefore seems to be that while in this country there is a growing feeling that the engineer should play a greater part in administration, in order that the gap between fundamental research and production shall be filled by a more complete translation into practice than exists at present, in the United States, where, according to some accounts, that gap is already filled it is considered the weaknesses of the engineer prevent his playing any great part except in a limited field. Even in that field his special knowledge and the efforts made to gain it are considered to be so unimportant that it has been stated by an influential American journal that "75 per cent. of the jobs for which engineers are hired could be filled by graduates with bachelor of arts degrees." If that be a true picture of the situation in that country (and we are not convinced that it is), it would seem that a radical change in the policy of reducing the number of arts students to so small a proportion of the whole will soon be necessary. For our part, we should naturally prefer to see more administrators and managers with engineering and scientific backgrounds. To ensure that position, however, raises another problem, since, as Mr. R. Birley, the Headmaster of Eton, has pointed out, there is a serious shortage of science masters in the schools and until the deficiency is made up the proposals outlined in *The Times* are quite unrealistic.

NOTES.

THE INSTITUTE OF METALS.

THE 40th annual autumn meeting of the Institute of Metals opened in the Town Hall, Lord-street, Southport, Lancashire, under the Presidency of Professor F. C. Thompson, on the evening of Monday, September 21, when the 24th annual autumn lecture was delivered by Dr. Maurice Cook. Before the delivery of the lecture, however, a short business meeting was held, during which the secretary announced that, as required by the Articles of Association, the following members would retire from the Council at the annual general meeting in April, 1954. These were: as President, Professor F. C. Thompson; as past president, Mr. H. S. Tasker; as vice-presidents, Mr. A. B. Graham and Mr. P. V. Hunter, C.B.E.; and as an ordinary member of Council, Dr. L. B. Pfeil, O.B.E., F.R.S. In accordance with the Articles, Professor F. C. Thompson would fill the vacancy on the Council as past-president, and the Council had nominated the following members to fill the other vacancies, namely, as President, Dr. S. F. Dorey, C.B.E., F.R.S.; as vice-presidents, Dr. Maurice Cook, Dr. L. B. Pfeil, O.B.E., F.R.S., and Major P. L. Teed; and as ordinary members of Council, Mr. R. D. Hamer and Mr. G. P. Tinker. The Council had further elected Dr. Maurice Cook to serve as senior vice-president for 1954-55, and he would be the Council's nominee for the Presidency in 1955-56. At the conclusion of the announcements Dr. Cook delivered the Autumn Lecture, which was entitled "The New Metal Titanium." We hope to reprint the lecture in a subsequent issue. In the course of the lecture, Dr. Cook spoke of the history, occurrence, reduction processes, melting, physical and mechanical properties, and alloys of titanium. He stated that the attractive strength: weight ratio was the feature of titanium and its alloys chiefly responsible for their demand for and use in aircraft, but the other excelling characteristic of the metal was its resistance to corrosion. The early optimism concerning this had been abundantly justified. In a series of tests in which titanium and austenitic stainless-steel impellers had been rotated at 300 r.p.m. in 40-per cent. boiling cupric chloride, cold *aqua regia*, boiling concentrated nitric acid, and heavily polluted seawater containing erosive silt, the titanium specimens had been practically unaffected after 500 hours while the stainless-steel impellers had all been seriously corroded, some after much shorter periods of time.

PITHEAD GEAR COLLAPSE AT EAST POOL MINE.

The wooden pithead gear at the well-known East Pool Mine at Camborne, Cornwall, collapsed on the afternoon of Tuesday, September 15, fortunately without causing any personal injuries. The mine has been closed since 1946, but the headgear was in use for maintenance work on the Cornish pump gear, which is pumping water from the adjacent. South Crofty Mine. The headgear, which was about 80 ft. high, carried two sheaves for normal cage-winding, and a single sheave for use with a steam capstan for changing pump rods in the shaft. The condition of the headgear has been poor for some time, and arrangements had been made to dismantle it. To enable winding and maintenance work to be carried on, a small wooden headgear had been erected inside the large one; this was almost complete, and it should have been possible to commence the demolition of the large one in a short time. On the morning of September 15, however, the large headgear showed signs that its collapse was imminent, and at 8 a.m. the pumping engine was stopped, as it was causing the structure to shake. The cages were brought up, and the winding ropes removed. Old boiler plates were then placed over the shaft to protect it. This work had just been completed, and the workmen had left, when several loud cracks gave final warning of collapse. At 4.40 p.m., on a completely windless day, the headgear finally failed, and fell to the ground. There were no personal injuries, as we have stated, and the damage to property was surprisingly small. The external parts of the 90-in. pumping engine, which is the property of the Cornish Engines Preservation Society, were untouched, but a part of the engine-house roof, about 8 ft. long, was damaged, as was the weather boarding at the point where the "bob" or beam projects. Other minor damage was caused to the engine house, and there was also a certain amount of damage to the small headgear which had been erected inside the large one. Clearance of the wreckage began at once, and it is hoped to resume pumping shortly.

THE LONDON CONTRACTORS' ACCIDENT PREVENTION GROUP.

A meeting of the London Building and Engineering Contractors' Accident Prevention Group was held on September 16 in the Safety-Health and Welfare Museum, Horseferry-road, S.W.1, the Chairman being Mr. W. Dawes, of the Woodall-Duckham Construction Company, Limited. A paper entitled "A Contractor's Safety Organisation" was read by Mr. Dawes, who described the safety organisation of his company. The paper was illustrated by copies of the various forms used for the initial reporting of an accident, the recording of the days and working hours lost due to an accident, and a consolidated monthly accident-report form. The discussion centred largely on the question whether a safety organisation should come under the personnel department of a large firm, or under the construction directorate; the consensus of opinion was in favour of the latter course, on the ground that a safety-officer should be intimate with constructional procedure, the methods used and the difficulties normally encountered. At the same time, it was conceded that, in the case of the smaller firms, the safety-officer might have to combine his duties with others, not excluding those of a personnel officer, in which case, however, it was still felt that, as a safety-officer, he should have constructional experience and be responsible to that side of management responsible for construction. The opinion was expressed that posters and literature alone were not so effective as when they were supported by personal approach and by the formation of safety committees from among the foremen and men employed.

JUBILEE MEETING OF THE OFFICERS' (MERCHANT NAVY) FEDERATION.

The annual general meeting of the Officers' (Merchant Navy) Federation, founded in 1928, was held in the Council Chamber of Lloyd's Register of Shipping, 71, Fenchurch-street, E.C.3, on September 17, the President, Captain W. H. Coombs, C.B.E., R.N.R., taking the chair. Moving the adoption of the annual report, Captain Coombs referred to the success which the Federation had achieved over the past 25 years. Speaking of the future, he said that, obviously, the officers of the Merchant Navy could only prosper so long as British shipping prospered. Unless shipowners could find the money to buy new ships at prices which would allow profitable operation, these ships would not be ordered or built. The shipowners had made a sound case for special consideration of the industry by the Inland Revenue authorities. The warnings of danger ahead had been sounded for a long time past, and they were justified. Orders for ships were being cancelled, and orders which should be placed, were not being placed because of the heavy rate of taxation and the high cost of shipbuilding. The virtual absence of orders for new tramp tonnage was particularly disturbing. Captain Coombs also pointed out that, whereas at one time Britain owned over 50 per cent. of the world's shipping, at the present time the tonnage owned was but 24 per cent. The motion for the adoption was supported by Sir Gilmour Jenkins, K.C.B., Permanent Secretary to the Ministry of Transport, and Vice-Admiral Sir Gilbert Stephenson, K.B.E. Sir Gilmour paid a tribute to the Federation for all the help and co-operation given to the Government. He cited the many difficulties encountered during the recent war and particularly mentioned the sending of ships to North Russia and Malta, under conditions of exceptional danger, and the manning of the invasion fleets, all of which raised personnel problems which

the Federation had helped greatly to solve. He also acknowledged the considerable help given by the Federation in framing the new safety rules affecting British shipping, which rules, he said, were a model for the world.

RESEARCH FELLOWSHIPS TENABLE IN THE UNITED STATES.

In response to a request from the Organisation for European Economic Co-operation, the United States Government has provided funds to enable 150 scientists from Europe to travel to and live in the United States for up to two years to study in American research institutions. The funds are available in the first instance until the end of 1955. The National Academy of Sciences, Washington, is administering the scheme and the Royal Society has accepted the invitation of the Academy to advise on the selection of candidates from the United Kingdom. Successful candidates, who will be required to return to scientific work in their own countries on completion of the Fellowships, will be placed in American universities working on current fundamental scientific research closely related to their own fields of interest. Opportunities may also be provided, towards the end of the tenure of the Fellowship, for work on problems in industrial or other laboratories. About 25 Fellowships will be open for award to candidates from the United Kingdom and it is expected that most of the successful candidates will be between 26 and 32 years of age. Applications will be considered from candidates who propose to do research in the natural sciences, including engineering. They must be in possession of a doctoral degree in science recognised in institutions of higher education or have equivalent experience. Applications, which may be made at any time, will be considered at regular intervals. For the first two sets of applications the closing dates are, respectively, October 1 and November 30, 1953. Forms of application and further information are obtainable from the assistant secretary, The Royal Society, Burlington House, London, W.1.

CREWE PUPILS' AND PREMIUM APPRENTICES' DINNER.

Mr. R. A. Riddles, C.B.E., who is retiring from the Railway Executive at the end of this month, took the chair at the 50th annual dinner of past and present Crewe pupils and "premiums," which was held at the Crewe Arms Hotel on September 21. The dinner is now re-established as an annual event (the last was held in 1939) and next year it will probably be held in London. The series was started in 1883, but has been interrupted by the wars and the General Strike of 1926. The toast of "Past and Present Crewe Pupils and Premiums" was proposed by the Rt. Hon. Lord Glyn of Farnborough, and responded to by Captain Reginald Terrell on behalf of past Crewe men and by Mr. H. J. Grant on behalf of present Crewe men. Mr. Riddles, in proposing the toast of "The Guests," referred particularly to Sir William Wood ("an old friend of Crewe"), Lord Monkswell, whose writings on railway subjects he recalled, Sir William Stanier, and Lord Glyn, who was the principal guest of the evening. Mr. J. W. Watkins, C.V.O., D.S.O., M.C., chief officer of the London Midland Region, responded, and Mr. John Shearman proposed a toast to the chairman. The dinner was attended by 68 past and present Crewe men and 22 guests, among whom were Mr. C. R. Mayo (trained at Crewe from 1895 to 1900), Mr. F. A. Lemon (1896 to 1899, and subsequently works superintendent), Mr. H. G. Ivatt (1904 to 1907), Mr. R. E. Trevithick (1909 to 1913), Mr. V. R. Bowen-Cooke (1916 to 1920), and Mr. Eric A. Robinson (1912 to 1919). Mr. Robinson is the honorary secretary for organising the dinners; his address is 53, Haymarket, London, S.W.1. On the following afternoon Mr. Riddles layed the foundation stone of the new apprentice training school which British Railways are having built on the bomb-damaged site of the former carriage works. It is hoped that this school will attract local boys when they leave day school, and will thus help to solve the problem of maintaining the staff of skilled artisans in the locomotive works. Trade apprentices will spend a year at the school and engineering apprentices four months.

THE INSTITUTION OF NAVAL ARCHITECTS' AUTUMN MEETING.

THE autumn meeting of the Institution of Naval Architects was held this year in Holland, by invitation of the corresponding Dutch society, the Koninklijk Instituut van Ingenieurs. The headquarters for the meeting was at the Kurhaus, Scheveningen, where the opening ceremony took place on Monday, September 14, and where the technical sessions and the official dinner was held on September 18. The programme, as arranged, was to devote September 14 to the opening and, in the evening, a reception by the Netherlands Government; September 15 and 16 to technical sessions, with a concert, by invitation, on the evening of September 15; September 17 to an all-day visit to Amsterdam; and September 18 to visits to Dordrecht and Rotterdam, with the dinner in the evening.

In fact, however, the programme was extended, the formal opening, which was an afternoon ceremony, being preceded in the morning by an informal address on the history and unique characteristics of the Netherlands, delivered by Professor Ir. H. E. Jaeger. On the following day, the Institution was honoured by a visit from H.R.H. the Prince of the Netherlands, to whom the President, the Rt. Hon. Viscount Runciman of Doxford, presented the diploma of honorary membership of the Institution; and later in the same day, the members and their ladies were afforded special facilities to witness the return of Her Majesty Queen Juliana from the State Opening of the Dutch Parliament. Finally, on Saturday, September 19, a party was organised to visit the reclamation works in eastern Flevoland, which is the latest stage in the draining of the former Zuider Zee.

The programme of papers read and discussed at the four technical sessions was as follows. In the morning of September 15, Professor Dr. Ir. W. P. A. van Lammeren read a paper on "The Present-Day Development of Ship Model Research in the Netherlands Ship Model Basin at Wageningen" (of which he is the superintendent); and, in the afternoon, Mr. J. Brown, B.Sc., and Mr. J. M. Ferguson presented a joint paper on "Tests of Launching Greases," which was followed by one on "Optical Marking-Off System for Plates and Sections in Shipbuilding," by Ir. J. H. Krietemeyer. On Wednesday, September 16, in the morning, Professor L. C. Burrill, M.Sc., Ph.D., read his paper "On Propeller Manufacture," and Dr. F. H. Todd, formerly of the National Physical Laboratory, and now of the David W. Taylor Model Basin at Carderock, Maryland, U.S.A., described "The Hydromechanics Research Programme of the Bureau of Ships, U.S. Navy." In the afternoon, Mr. T. W. Bunyan, B.Sc., of the research department of Lloyd's Register of Shipping, presented the concluding paper of the meeting, on "Investigations of Ships' Hull and Machinery Defects."

THE NETHERLANDS.

Professor Jaeger described his address as "an informal talk on the Netherlands" by "a man interested in the culture, history, geography and biology of this country and yours, having at the same time the distorted mind of a shipbuilder." The historical centre of the country, he explained, was the old province of Holland, formerly the most important of the Seven Provinces which made up the original Dutch Republic, and still the home of half of the present population of ten millions. The density of population in the Netherlands, he continued, was twice that of Great Britain; in fact, "if the density of the population of the United States was as high, there would now be 2,250 million Americans instead of 180 millions—more than the whole population of the earth." The dense population—growing at the rate of 100,000 a year—was a serious problem, but it was being met in part by the immense programme of land reclamation. The first proposal to drain the Zuider Zee was formulated in 1667 by Hendric Stevin, but the resources then available were not equal to the task. In 1918, however, the proposal of Dr. C. Lely, then the Minister of Public Works, was adopted. When completed, it would increase the country's agricultural acreage by 10 per cent. and its territory by 7 per cent. The dyke which closed the Zuider Zee was 30 km. long and enclosed 3,500 sq. km., of which 2,250 sq. km. would eventually become polderland. The remainder would be retained as a lake, which was necessary to ensure a proper regulation of the water and the efflux of river water. By 1930, the Wieringer Polder—the first of the five new polders—had been drained. The second, the North-East Polder, was drained in 1942; the enclosing dyke was 55 km. long, and two years were occupied in pumping out the water at the rate of 4½ million litres a minute. Future projects, Professor Jaeger mentioned, included the construction of a dyke across the delta of the Rhine and Meuse, similar to the Zuider Zee dyke and about 270 ft. wide.

The President, in proposing a vote of thanks to Professor Jaeger, said that his talk had been extraordinarily interesting, and explained much better than any guide book the problems with which the people of the Netherlands were faced, and the courage and ingenuity with which they had been tackled.

OPENING CEREMONY.

The chair was taken at the opening ceremony by Mr. L. Neher, deputising for Dr. J. A. Ringers, President of the Koninklijk Instituut van Ingenieurs, who had been prevented by business reasons from being present. Mr. Neher recalled that 30 years had elapsed since the previous visit of the Institution of Naval Architects to Holland. The work of naval architects, he continued, was of prime importance to world economics, and he hoped that the congress would further their efforts.

The President, in reply, expressed the thanks of the Institution for the welcome extended to the members, and for an address which outlined and underlined a great deal of what lay and must lie at the heart of the activities of such an institution. "When it comes to comparing shipbuilding and aircraft construction, and the publicity which each achieves," he continued, "I expect one of the reasons why the aircraft constructors get more publicity than we do is that they are a great deal further off designing a perfect aircraft than we are from designing a perfect ship. They can report good progress at fairly frequent intervals, whereas we have reached the stage when the likelihood of any single spectacular change in the general methods of designing or even propelling a ship cannot be expected every day. But what does happen from day to day is continuous improvement, very often in small stages, of a techniqu which, after all, must have started several thousand years ago so far as ships' hulls are concerned; and although we are farther ahead than the aircraft constructors, nevertheless our technique is capable of continuous small improvements. It is because we have reached a stage in ship economics where those small improvements are so intensely valuable in the commercial sense, that it is important to keep our standards high, to keep our research going and, above all, when we have the friendly relationships existing between us, to make quite sure that we exchange our knowledge freely and fully for the benefit of us both."

Lord Runciman took the chair on the morning of September 15 at the first of the technical sessions and invited Professor van Lammeren to deliver the first paper.

THE WORK OF THE WAGENINGEN TANK.

Professor van Lammeren's paper was divided into two parts, the first dealing with "Research aiming at Improvement in Hull Forms, Propellers and Rudders" and the second with "Research dealing with the Correlation between Tank Results and Trial-trip and Service Results"; the latter attracted the most attention in the meeting, as it described the work carried out with the 72-ft. self-propelled launch D. C. Endert, Jr., and was illustrated with a film showing the vessel under test at Kreljavice, on the Adriatic, whither she had been taken in search of assured smooth-water conditions. The first part of the paper, however, was also of considerable interest, and included an intimation that, before long, the department of naval architecture at the Technical University of Delft would be

provided with a towing tank 330 ft. long and 13 ft. 8 in. by 7 ft. 3 in. in cross section, a cavitation tunnel, and a flow-tank for experiments on river vessels; thus it would be able to relieve the staff at Wageningen of some of their research work. Meanwhile, said Professor van Lammeren, work was proceeding on hull forms, more especially with systematically-varied ship models; on systematic propeller series and the development of propeller theory, with special reference to the application of the so-called von Karman-Trefftz or Walchner profiles, having a curved back and pressure sides, following circular arcs; the investigation of hull form and propeller together, with particular regard to cavitation characteristics and efficiency; and, finally, on rudders. The second part of the paper was devoted to the influence of scale effect; the influence of roughness of the hull—which was one of the subjects investigated with the aid of the launch, D. C. Endert, Jr.; the influence of flowing and restricted water (e.g., the flow round a ship's hull); and the influence of "wind and seaway" (to quote the author's summary) and the scale effect, between model and ship, for which allowance should be made. In dealing with the last-mentioned section, the author emphasised the great importance of collecting, carefully and systematically, the maximum number of trial-trip and service results of ships, and analysing them for future use; this was being done, he stated, by Professor Bonebakker, of the Technical University at Delft. He also emphasised the desirability of testing models systematically, under artificially-excited complex systems of waves and wind, the force and direction of which could be varied at will.

Discussion.

Dr. R. W. L. Gawn, who opened the discussion, said that the paper gave every assurance that the fine achievements of ship-model research in the Netherlands in the past would be more than maintained in the future. Fig. 1 in the paper was a very good statistical presentation of the results of the model tests of the particular ship concerned; but it was not very useful for comparison with other ships of different sizes. He invited the author's attention to the old "elements of form" diagram proposed by R. E. Froude, which gave much more information over a range of displacement. It was one which, at Haslar, he had found to be extremely useful. He noted that the author proposed to carry out open-water tests on much larger propeller models than formerly, i.e. on models 42 cm. in diameter (about 16½ in.) in lieu of the 24 cm. diameter adopted for the earlier Wageningen series. That change was to be commended, because there was a possibility of a disturbing scale effect on the smaller series. He was interested in the author's comments on propeller theory, and his reference to the mathematical maze presented by the calculation of some of the correction factors. Nevertheless, the theory was useful in a comparative sense, although it had limitations in an absolute sense.

Dr. van Lammeren mentioned the avoidance of cavitations with hollow-face blade sections; but it was as well to be cautious, for although, with certain classes of propeller, improvement could be achieved with the conveniently named "constant velocity" sections, he did not think it could be assumed that that would apply for every type of propeller. The device referred to for inducing a controlled velocity field in the cavitation tunnel was interesting, and he would like to have some particulars of it. The author seemed to deprecate the use of wire meshes. He (Dr. Gawn) had had a good deal of experience with wire grids; the term "grid" was used, and not "mesh," because the components were rods, of much larger diameter than small wires. By grading the sizes and the spacing of the members logically, very useful results could be obtained.

With regard to the ambitious and very thorough programme of trials on the D. C. Endert, Jr., he asked what led the author to prefer a course in Jugoslavia? Geographically, the Norwegian fjords and the Scottish lochs were nearer. Was he certain that the distance astern of the ship model when being towed for resistance tests was sufficient to avoid any effect of propeller action on the towed model? When using tugs, even at a distance of several ship's lengths, the propeller race had still a very significant influence. In the self-propelled test, was the propeller pitch adjusted to compensate for the greater resistance due to the scale of the model or did it run at greater revolutions?

Dr. G. Hughes said that the paper did not lend itself to much technical discussion, for it did not contain results; but it was useful in that it gave a survey of the kind of work that was being done on ship-form and related matters. At the National Physical Laboratory, they had been pursuing ship-model correlation work so far as they were able to do so within the limitations of the tank. On the friction side, they had carried out a fairly ambitious programme with planks and models. Professor van Lammeren referred to the more fundamental research which was being carried out at Wageningen in the field of frictional resistance, and spoke of the work with plates at very low Reynolds numbers. At Teddington, they had carried out very similar tests and had reached a Reynolds number about half the low value given in the paper. The author referred also to the necessity of determining the resistance of turbulence stimulators. Dr. Hughes asked what type of stimulator was used and how their resistance was determined, because in his own work in that range he found it impossible to measure or estimate the resistance of the stimulator itself. As to the effect of form, it was quite clear from work done in recent years that form drag, in addition to the purely frictional part of the resistance of the model, was subject to some scale effect. It had been the custom to estimate the ship results by correcting for the estimated skin friction of the model according to laws deduced from plane surface work; but clearly it was necessary to introduce a correction for form drag. He was pleased that the matter was being pursued so vigorously at Wageningen. At Teddington also a lot of work had been done on it. He was sure that, when the results of the work on both sides were published, they would have made a good step forward towards finding the correct answer for the ship.

(To be continued.)

AIRCRAFT DISPLAY AT FARNBOROUGH.

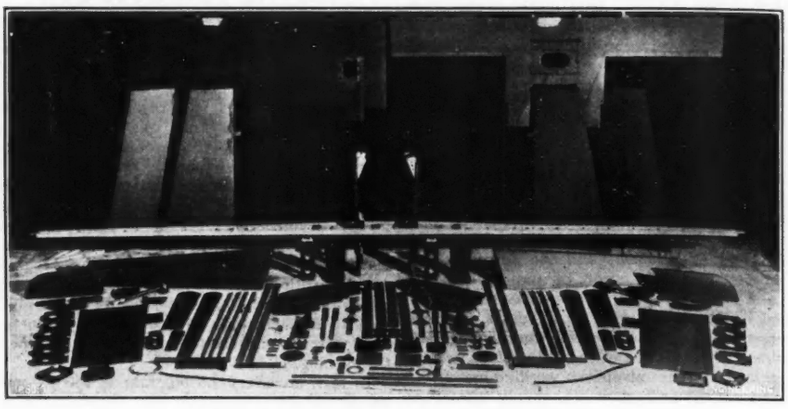


Fig 11. Tail-Plane Parts of Conventional Manufacture.

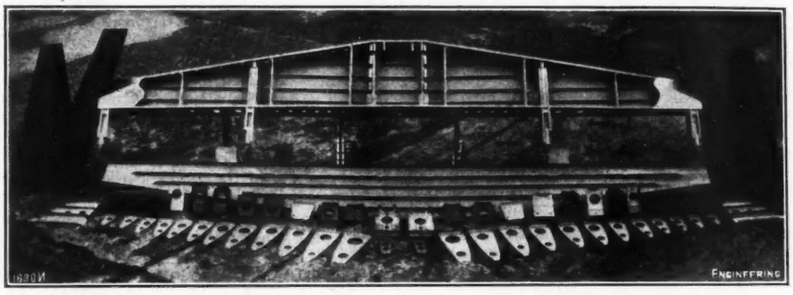


Fig. 12. Machined Tail-Plane Parts.

THE AIRCRAFT INDUSTRY'S DISPLAY AT FARNBOROUGH.

(Concluded from page 375.)

Several examples of new developments in constructional methods were on view in the static show this year. On the one hand, there are the approach towards simpler and less costly methods of manufacture, represented by the "tensioned skin" fuselage panel displayed by Aviation Traders (Engineering), Limited, Stansted Airport, Bishop's Stortford, Essex; an account of this method was given on page 311, *ante*. On the other hand, there was the quest for obtaining a high degree of structural stiffness and surface smoothness necessary for supersonic military aircraft, and two firms were showing examples of "integral construction" developed with this end in view.

Integral Construction.

A paper on "Integral Construction," by Mr. E. D. Keen, was read before the Royal Aeronautical Society in April, and was summarised on page 393 of our 175th volume (1953), in which methods of machining structural components from the solid, developed by Sir W. G. Armstrong Whitworth Aircraft, Limited, Baginton, Coventry, were described. This firm displayed a Meteor N.F.11 tailplane in which the box spar is machined from the solid; in Fig. 12 are shown the component parts of the tail plane, and, for comparison, Fig. 11 shows the components of the night-fighter tailplane of conventional riveted construction. It will be appreciated from these illustrations that, although integral construction calls for the installation of costly machinery, it can result in considerable savings in assembly time.

Another example of integral construction was a box spar exhibited by Short Brothers and Harland, Limited, Queen's Island, Belfast, illustrated in Figs. 13 and 14, opposite. It consists of upper and lower machined planks, with integral webs, and ribs riveted through intercostal boundary angles to the upper and lower planks. The ribs are stiffened by Redux-bonded angles. The planks are machined

AIRCRAFT DISPLAY AT FARNBOROUGH.

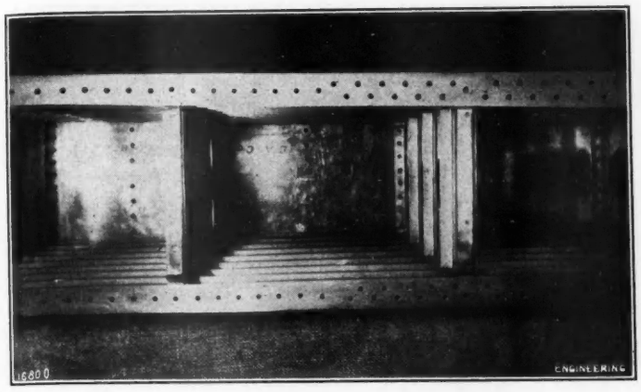


FIG. 13. INTEGRALLY-STIFFENED BOX SPAR.

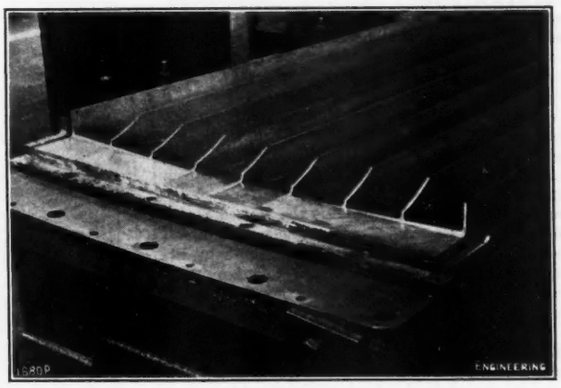


FIG. 14. MACHINED PLANK FOR BOX SPAR.

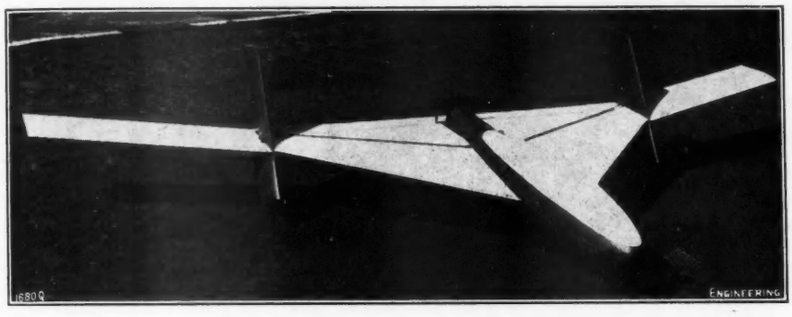


FIG. 15. HIGH-SPEED TOWED TARGET.

from solid light-alloy billets; they taper in overall width, flange thickness, web thickness, depth, and spacing. Rough machining was carried out with the material in the solution-treated condition, after which partial ageing was carried out. After completing machining operations, the material was aged fully, in which condition it is equivalent to DTD 646.

CORRUGATED REDUX-BONDED WING-SKIN STRUCTURE.

Short Brothers and Harland, Limited, also showed a double wing-skin construction, evolved to reduce weight and the number of detailed parts, by cutting out spanwise stringers and increasing the span between the ribs, in which a corrugated inner skin is Redux-bonded to the outer skin. Both inner and outer skins are of 26-s.w.g. DTD 687, and were shaped to profile before bonding, excepting the leading-edge under surface, which was rolled after bonding. Redux-bonding was carried out by the vacuum process. The construction of the main spar and ribs is orthodox. Similar structures have also been made in 30-s.w.g. sheet.

HIGH-SPEED TOWED TARGET.

Another example of new constructional methods which will probably be used increasingly in components such as control surfaces and helicopter blades, was seen in the high-speed towed target exhibited in the static park by Air Service Training Limited, Hamble, Hampshire, and illustrated in Fig. 15. The wings, fin, and forward part of the body of this target comprise a light-alloy skin, of relatively light gauge, stabilised with a low-density foam resin of the Sebalkyd type. For this application, the foam filling also has the advantage of localising damage due to hits with cannon shells or bullets, and is easily repaired; and, in the body, it provides the ballast necessary to ensure adequate longitudinal stability.

A basically all-wing layout, to give maximum target area and minimum drag, has been selected, with a centre-section body to facilitate sighting at altitude and to house the necessary equipment. The target is towed by a twin-bridle tow gear on a fixed tow bar at the nose. It can be trimmed longitudinally by a speed-controlled elevator which operates against a spring between stops. The position of the target relative to the towing aircraft can be varied by adjusting the downward stop position. For speeds at and below the aircraft approach speed, the elevator keeps the tow angle constant, thus facilitating "talk-down" landings.

Although the designers consider that the large wing area will render the use of a radar responder unit unnecessary, provision has been made for stowing such a unit in the body. There is also space for an air-firing error indicator unit. The target is fitted with a tricycle undercarriage, the rear wheels being housed in the lower part of the fins, giving a large wheelbase. The wheels are faired within the limits imposed by ground clearance, and are provided with "single-shot" expendable shock absorbers. A braking parachute, housed in the body, is released by the travel of any of the wheel units under landing loads. The tow-cable locks are also opened by the landing reaction.

MOULDED PLASTIC WING.

The Bristol Aeroplane Company, Limited, Filton, Bristol, showed a plastic wing structure developed during several years' research on the applications of plastics to primary aircraft structure. The wing shown was designed for high subsonic speeds, and the manufacturers claim that it is about 10 per cent. more efficient, on a strength-to-weight basis, than an equivalent aluminium-alloy structure. It has a span of 10·5 ft., an area of 36·25 sq. ft., a thickness/chord ratio of 7 per cent., and a sweepback of 30 deg. at 50 per cent. chord. It comprises four asbestos-phenolic mouldings, formed under high pressure between the mating surfaces of metal tools, at 150 lb. per square inch pressure, at a rate of about one moulding per hour. The port and starboard wing sections consist of two mouldings glued together on the median plane. The two sections are assembled at the wing centre line by glued buttstraps.

"BEVERLEY" MILITARY TRANSPORT AIRCRAFT.

Taking part in the flying display for the first time was the Beverley military transport aircraft, designed and constructed by Blackburn and General Aircraft, Limited, Brough, East Yorkshire. It is illustrated in Fig. 16, on page 406. The Beverley, developed from the Mark 1 Universal Freighter and powered by four Bristol Centaurus engines, flew for the first time in June, and has been ordered for service with the Royal Air Force. It is designed for carrying heavy and bulky freight loads, with hydraulically-operated "clamshell" doors at the rear of the fuselage into which tanks, motor vehicles, etc., can be loaded by means of loading ramps, which can be carried in the fuselage. There is accommodation in the tail boom for 42 troops.

To permit take-off and landing from grass airfields of comparatively small size, the Beverley has a moderate wing loading and is fitted with a tricycle undercarriage comprising two four-wheeled bogies, all eight wheels being fitted with hydraulically-operated disc brakes and a steerable twin nose-wheel; reversible-pitch de Havilland propellers, with hollow steel blades, are fitted. The ground-manœuvring qualities thereby achieved are quite remarkable. To reduce maintenance operations to the minimum, the undercarriage is non-retractable.

Information on the military Beverley is still restricted but a good idea of its capabilities may be obtained from its projected civil version, the Universal Freighter Mark 2, which has great possibilities for car-ferry operations. The civil Universal Freighter Mark 2 will have an all-up weight of 130,000 lb. and a maximum payload of 44,000 lb. The main freight compartment has an unobstructed floor space of 40 ft. by 10 ft., with 10 ft. head room. The floor is stressed to withstand a distributed loading of 21 lb. per square inch and a maximum axle load for vehicles of 9,000 lb.; it is provided with 170 lashing points, all fittings being capable of carrying an ultimate load of 5,000 lb. Forty-eight rotatable lashing shackles for attachment to any of these fittings are stowed in the hold, and there are also three horizontal rows of 1-ton lashing rings along each side wall of the freight compartment. A loading winch, or alternatively, an overhead gantry, can be supplied to facilitate loading and unloading.

At its maximum all-up weight, the civil Universal Freighter Mark 2 requires only a 1,000-yard grass strip for take-off and landing. It has a maximum weak-mixture cruising speed of about 200 m.p.h. The total fuel capacity, carried in flexible bag tanks in the wings, is 6,830 gallons. With fuel reserves as laid down in the Society of British Aircraft Constructors' standard method for estimating direct operating costs, a pay load of about 4,000 lb. can be carried over the maximum stage length of 3,000 miles; over a stage length of 1,500 miles, a payload of 25,000 lb. can be carried; and the maximum payload, of 44,000 lb., can be carried 250 miles.

AIRCRAFT DISPLAY AT FARNBOROUGH.

"BEAVER" SERIES 2 LIGHT TRANSPORT AIRCRAFT.

For the first time, de Havilland Aircraft of Canada, Limited, Toronto, Ontario, demonstrated their six-seat Series 2 Beaver light transport aircraft. The earlier version, the Series 1 Beaver, has never been shown at Farnborough since it is powered by an American Pratt and Whitney Wasp Junior 450-h.p. engine, whereas the Series 2 is fitted with an Alvis Leonides 550-h.p. engine and a three-blade de Havilland Hydromatic propeller. The Series 1 Beaver, developed in the first place for the special needs of the Canadian bush operator, i.e., for operation in extremes of climate and from restricted spaces, with the minimum of maintenance, has been widely used by the United States Army and Air Force in Korea. The later Series 2 Beaver, with enhanced power, has a better take-off, climb and cruise performance, and, on account of the higher windmilling drag of the three-blade propeller (the earlier version had a two-blade propeller), better approach and landing behaviour.

As may be seen from Fig. 17, the Beaver Series 2 is a high-wing all-metal braced monoplane of rectangular wing-plan form, with a fixed tailwheel undercarriage, which is interchangeable with skis or a float chassis. Goodyear disc brakes are fitted to the main wheels, and the tailwheel is steerable. Large slotted flaps, hydraulically operated, are fitted; a certain amount of aileron droop is provided when the flaps are lowered. The fin and tail surfaces are large; adjustable trimming tabs are provided on the elevator and rudder. The cabin floor has been designed to carry concentrated loads, and a hatch in the rear wall of the cabin allows long pieces of freight to be loaded into the rear fuselage. The wing is stressed for carrying external stores. The total fuel capacity is 113 Imperial gallons, carried in three fuselage tanks and two integral tanks in the wing tips.

The Beaver has a span of 48 ft. 8 in. and an overall length of 31 ft. 9 in. The maximum all-up weight is 5,100 lb. With 1,000 lb. of payload and full military equipment, corresponding to an all-up weight of 4,950 lb., the performance is as follows: take-off distance, to clear a 50-ft. obstacle, 700 ft.; maximum rate of climb at sea level, 1,560 ft. per minute; cruising speed, 156 miles per hour; endurance, 6·5 hours; landing distance, to clear a 50-ft. obstacle, 760 ft.

FLYING TEST-BEDS.

Formidable climbing performances were shown by two "flying test-beds" taking part in the flying display. The Olympus Canberra flying test-bed was sponsored by the Bristol Aeroplane Company, Limited, Filton, Bristol, the designers and constructors of the Olympus "two-spool" two-stage axial-flow jet engine which has undergone a considerable amount of development testing since the announcement, last year, that it develops a thrust of 9,750 lb. Since the first public demonstration of the Olympus Canberra at Farnborough in 1952, it has established a new world height record for aeroplanes, of 63,668 ft. To accommodate the Olympus engines, the wing structure has been strengthened with additional and heavier ribs and rib booms. The nacelles, rather larger than on the standard aircraft, extend farther forward from the leading edge. Test instruments and two automatic-observer cameras are installed in the bomb bay, and further test equipment has been fitted in place of one of the ejector seats.

Rolls-Royce Limited, Derby, also demonstrated a Canberra flying test-bed powered by two Avon RA 14 axial-flow jet engines. This Avon engine was also on view on their stand in the static exhibition, and is illustrated in Fig. 18, opposite. The Avon RA 14 develops a static thrust at sea level of 9,500 lb., without reheat, and is the most powerful British type-tested engine. The following particulars of the Avon RA 14, which is claimed to have the lowest specific weight and the highest thrust per unit frontal area yet achieved, have been released: specific fuel consumption, 0·84 lb. per pound-thrust per hour; net dry weight, 2,860 lb.; maximum diameter, 41·5 in.; specific weight, 0·30 lb. per pound thrust; thrust per unit frontal area, 1,012 lb. per square foot. The Avon RA14 is in production and deliveries have already commenced. A civil version of the engine, the RA 16, developing 9,000 lb. thrust, is to be fitted in the de Havilland Series 3 Comet air-liner.

FIG. 16. "BEVERLEY" MILITARY TRANSPORT AIRCRAFT.

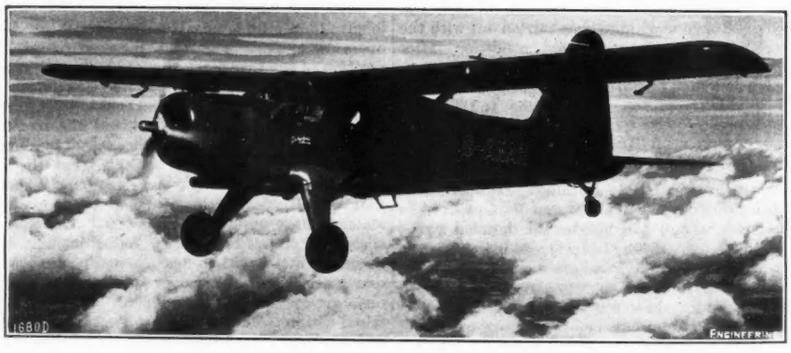


FIG. 17. "BEAVER" SERIES 2 LIGHT TRANSPORT AIRCRAFT.

NEW POWER UNITS.

For the first time, some of the power units under development for helicopter rotor blade-tip propulsion were on view; the Saunders-Roe 45-lb. thrust jet has already been described briefly, on page 319, *ante*. The Fairey Aviation Company, Limited, Hayes, Middlesex, were also showing a pulse jet, capable of delivering 25 lb. thrust and weighing 8½ lb.; and a blade-tip pressure jet, in which fuel is injected and burned in compressed air supplied through the hollow rotor blade. This latter unit develops 600 lb. thrust and weighs 27·75 lb.

A different type of power unit development, illustrated in Fig. 19, opposite, is the Super Sprite liquid-free rocket motor developed recently by the de Havilland Engine Company, Limited, Edgware, Middlesex, brief particulars of which were given on page 287, *ante*. It may be recalled that this engine has been developed in the first place for assisting the take-off of military aircraft. It weighs about 600 lb. empty, and develops a total impulse of 120,000 lb.-sec. over a total duration of about 40 seconds, giving a maximum thrust of 4,000 lb. (The original Sprite engine, from which the Super Sprite has been evolved, developed a total impulse of 55,000 lb.-sec.) The Super Sprite uses a solid catalyst and hydrogen peroxide as the oxidant with kerosine or petrol fuel injection. In the original statement issued by the de Havilland company, it was said that the fuel was drawn from the aircraft fuel tanks; the Company have since corrected this statement. The fuel is, in fact, carried in a tank integral with the structure of the rocket motor.

MINISTRY OF SUPPLY EXHIBITS.

Among the exhibits shown on the Ministry of Supply stand were two cameras, specially developed for night photography from high-speed aircraft at low and high altitudes, respectively, of light-weight fabricated construction and provided with image-movement compensation; instrumentation developed for testing automatic pilots in flight; the

AIRCRAFT DISPLAY AT FARNBOROUGH.

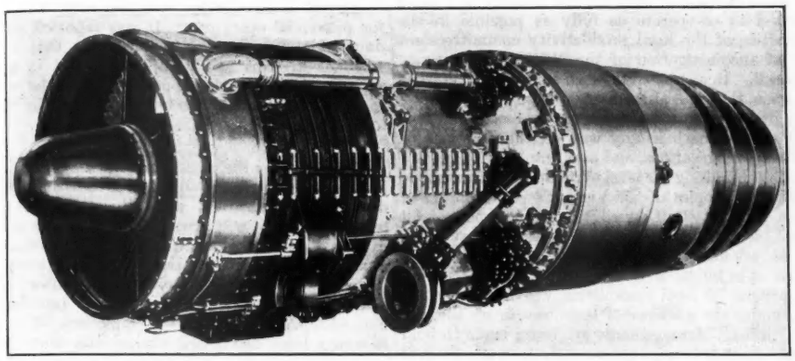


FIG. 18. ROLLS-ROYCE "AVON" RA14 ENGINE.

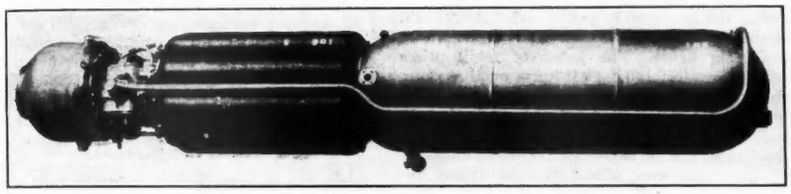


FIG. 19. "SUPER SPRITE" ROCKET MOTOR.

continuous fire-detector system developed commercially by the Graviner Manufacturing Company, Limited, Poyle Mill Works, Colnbrook, Buckinghamshire, which employs a temperature-sensitive material developed by the Chemistry Department of the Royal Aircraft Establishment; and a fatigue meter, or counting accelerometer, for recording the number of occurrences of various loads of given magnitudes encountered by an aircraft in flight.

Two rocket motors, the Ladybird and the Scarab, developed by the Rocket Propulsion Department of the Royal Aircraft Establishment for assisted take-off, were on view. The Scarab and Ladybird produce, respectively, mean thrusts of 3,000 lb. and 1,500 lb. for approximately six seconds, giving total impulses of 20,000 lb.-sec. and 10,000 lb.-sec. They weigh, respectively, 175 lb. and 100 lb. Each motor contains a cordite charge in a 45-ton tensile steel case, the latter being made either by a cold drawn process by the Chesterfield Tube Company, Limited, Chesterfield, or from welded sheet steel by an automatic process developed by British Messier, Limited, Gloucester.

Another exhibit by the Royal Aircraft Establishment was a pressure scanner for flight investigations which enables 20 pressures to be displayed consecutively on a differential pressure gauge. The 20 pressures to be measured are connected by short rubber tubes to a common ring. The tubes are clamped shut by rockers held down by leaf springs. Each rocker, in turn, is raised to allow the corresponding pressure to be communicated to the recording gauge. When the instrument is not in use, the rockers can be raised so that the tubes are not continuously compressed. Microswitches operate the recording camera, and shut off the driving motor when the scan is complete; a scan takes about 30 seconds. Four such pressure scanners, operated by a single electric motor, are at present installed in a Vampire aircraft used for experiments on boundary-layer control

This concludes our description of some of the exhibits at Farnborough. In the static exhibition hall, there were more than 200 stands, and, apart from the few examples cited of engines and constructional exhibits, it has not been possible to mention the many interesting developments in accessories, equipment, instruments, radio and materials that were on view. These developments, however, very often make possible the more spectacular and widely-publicised developments in aircraft design and construction.

FORTHCOMING EXHIBITIONS AND CONFERENCES.

THIS list appears in the last issue of each month. Organisers are invited to send to the Editor particulars of forthcoming events.

NATIONAL RADIO, TELEVISION AND ELECTRONICS EXHIBITION.—Friday, September 25, to Saturday, October 10, in Paris. Further information obtainable from the Salon de la Radio, de la Television et de l'Electronique, 23 Rue de Lubeck, Paris.

GERMAN INDUSTRIES EXHIBITION.—Saturday, September 26, to Sunday, October 11, in Berlin. *Agents:* The Berlin Marketing Council, Empire House, 175, Piccadilly, London, W.1. (Telephone: REGent 4584.)

THIRD INTERNATIONAL COTTON, RAYON, TEXTILE MACHINERY AND CHEMISTRY EXHIBITION.—Saturday, September 26, to Sunday, October 11, at Busto Arsizio. Further particulars obtainable from la Direzione, Mostra del Cotone e del Rayon, Via Mameli 1, Busto Arsizio, Italy.

SEVENTEENTH INTERNATIONAL TRADE FAIR.—Saturday, September 26, to Monday, October 12, at Metz. *Agents:* Auger and Turner Group, Ltd., 40, Gerrard-street, London, W.1. (Telephone: GERrard 6671.)

ELECTRONICS COURSE AT HARWELL.—Monday, September 28, to Friday, October 2, at the Isotope School, Atomic Energy Research Establishment. Apply to the Electronics Division, A.E.R.E., Harwell, Berkshire. (Telephone: Abingdon 620.) See also page 198, *ante*.

EIGHTEENTH INTERNATIONAL NAUTICAL EXHIBITION.—Tuesday, September 29, to Wednesday, October 14, in Paris. *Agents:* Auger and Turner Group, Ltd., 40, Gerrard-street, London, W.1. (Telephone: GERrard 6671.)

IRON AND STEEL INSTITUTE SPECIAL MEETING.—Wednesday, September 30, to Wednesday, October 7, in the Netherlands. Further information obtainable from the secretary, the Iron and Steel Institute, 4, Grosvenor-gardens, Westminster, London, S.W.1. (Telephone: SLOane 0061.) See also page 111, *ante*.

40TH FRENCH MOTOR AND CYCLE EXHIBITION.—Thursday, October 1, to Sunday, October 11, at the Grand Palais and Porte de Versailles Fair Grounds, Paris. Further particulars obtainable from the Chambre Syndicat des Constructeurs d'Automobile Grand Palais, Avenue Alexandre II, Paris, 8e.

BUSINESS MACHINES AND OFFICE EQUIPMENT EXHIBITION.—Wednesday, October 7, to Sunday, October 18, in Paris. Organised by the Salon Internationale de l'Equipment de Bureau, 6, Place de Valois, Paris.

AMERICAN SOCIETY OF AUTOMOTIVE ENGINEERS: NATIONAL AERONAUTICAL MEETING, AIRCRAFT ENGINEERING DISPLAY AND AIRCRAFT PRODUCTION FORUM.—Wednesday, October 7, to Saturday, October 10, at Los Angeles, California. Apply to the secretary of the Society, 29, West 39th-street, New York 18, U.S.A.

INTERNATIONAL ENGINEERS' CONGRESS, ITALY.—Thursday, October 8, to Sunday, October 11, at the Termini Station Buildings, Via Giolitti, Rome. Further particulars from the congress secretariat, Associazione Nazionale Ingegneri ed Architetti Italiani, 90 Via Terme Diocleziano, Rome. See also page 198, *ante*.

FIFTH INTERNATIONAL MECHANICAL ENGINEERING CONGRESS.—Friday, October 9, to Thursday, October 15, at Turin. Organised by the Associazione Industriali Metallurgici Meccanici Affini, Via Massena 20, Turin. Applications to be sent to the director, British Engineers' Association, 32, Victoria-street, London, S.W.1. (Telephone: ABBey 2141.) See also page 63, *ante*.

ENGINEERING INDUSTRIES ASSOCIATION: LONDON REGIONAL DISPLAY.—Tuesday, Wednesday and Thursday, October 13, 14 and 15, at the Horticultural Hall, Vincent-square, London, S.W.1. Apply to the secretary of the Association, 9, Seymour-street, Portman-square, London, W.1. (Telephone: WELbeck 2241.)

INTERNATIONAL TEXTILE MACHINERY AND ACCESSORIES EXHIBITION.—Wednesday, October 14, to Saturday, October 24, at Belle Vue, Manchester. Organised by the Textile Recorder Machinery and Accessories Exhibitions, Ltd., Old Colony House, South King-street, Manchester, 2. (Telephone: Blackfriars 7234-6.)

SECOND INTERNATIONAL BICYCLE AND MOTOR-CYCLE EXHIBITION.—Sunday, October 18, to Sunday, October 25, at Frankfurt. Apply to Messe- und Ausstellungs-Gesellschaft m.b.H., Frankfurt-am-Main.

INTERNATIONAL MOTOR SHOW.—Wednesday, October 21, to Saturday, October 31, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

SIXTH SALON FOR THE PACKAGING AND CONDITIONING INDUSTRIES.—Saturday, October 31, to Sunday, November 15, at Brussels. Further particulars obtainable from the Salon de l'Emballage et des Industries Connexes, 10, Place de Brouckere, Brussels.

MECHANICAL HANDLING EXHIBITION.—Tuesday, November 3, to Wednesday, November 11, in Paris. Apply to the Salon de la Manutention, 40 Rue de Colisée, Paris, 8e.

SEVENTH INTERNATIONAL PACKAGING, PRESENTATION AND DISTRIBUTING METHODS EXHIBITION.—Tuesday, November 3, to Wednesday, November 11, in Paris. Further information obtainable from the Salon de l'Emballage, 40 Rue de Colisée, Paris, 8e.

FOOD INDUSTRIES AND TRADES EQUIPMENT EXHIBITION.—Tuesday, November 3, to Wednesday, November 11, in Paris. Apply to the offices of the exhibition, 42, Rue du Louvre, Paris.

MONTREAL TOOL AND EQUIPMENT SHOW.—Monday, November 9, to Friday, November 13, at the Show Mart, Montreal. Communications to the offices of the Show, 4585, Sherbrooke-street West, Montreal.

SCOTTISH MOTOR SHOW.—Friday, November 13, to Saturday, November 21, at Kelvin Hall, Glasgow. Apply to the Scottish Motor Trades Association, Ltd., 3, Palmerston-place, Edinburgh, 12. (Telephone: Central 3643.)

CYCLE AND MOTOR CYCLE SHOW.—Saturday, November 14, to Saturday, November 21, at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Manufacturers' and Traders' Union, The Towers, Warwick-road, Coventry. (Telephone: Coventry 62511.)

FUEL EFFICIENCY EXHIBITION.—Saturday, November 14, to Saturday, November 21, at the City Hall, Manchester. Applications to Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. (Telephone: Deansgate 6363); or to the London agent at 167, Oakhill-road, Putney, London, S.W.15. (Telephone: VANdyke 5635.)

BUILDING EXHIBITION.—Wednesday, November 18, to Wednesday, December 2, at Olympia, London, W.14. Apply to the organisers: Building Trades Exhibitions, Ltd., 4, Vernon-place, London, W.C.1. (Telephone: HOLborn 8146-8.)

31ST INTERNATIONAL BICYCLE AND MOTOR-CYCLE SHOW.—Saturday, November 28, to Tuesday, December 8, in the Mechanical Engineering Pavilion, Milan Samples Fair. Additional information obtainable from the Associazione Nazionale del Ciclo, Motociclo ed Accessori, Via Mauro Macchi 32, Milan, Italy.

SMITHFIELD SHOW AND AGRICULTURAL MACHINERY EXHIBITION.—Monday, December 7, to Friday, December 11, at Earl's Court, London, S.W.5. Details obtainable from the Smithfield Show Joint Committee, 148, Piccadilly, London, W.1. (Telephone: GROsvenor 4040.)

CONFERENCE ON THE NORTH SEA FLOODS.—Wednesday and Thursday, December 16 and 17, at the Institution of Civil Engineers, Great George-street, Westminster, London, S.W.1. Further particulars obtainable from the secretary of the Institution at the above address. (Telephone: WHItehall 4577.) See also page 127, *ante*.

AUSTRALIAN AND NEW ZEALAND ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, GENERAL MEETING.—Wednesday, January 13, to Wednesday, January 20, 1954, in Canberra. Apply to Professor A. H. Corbett, Royal Military College, Duntroon, A.C.T., Australia.

INTERNATIONAL EXHIBITION ON LOW-COST HOUSING.—Wednesday, January 20, to Friday, March 5, 1954, at the Old Fort, New Delhi, India. Organised by the Ministry of Works, Housing and Supply of the Government of India. Apply to the Director of the exhibition, "P" Block, New Delhi, India.

CANADIAN CONFERENCE ON PRESTRESSED CONCRETE.—Thursday and Friday, January 28 and 29, 1954, in Toronto. Further particulars obtainable from Mr. H. Fealdman, secretary, organising committee, Canadian Conference on Prestressed Concrete, Hydro-Electric Power Commission of Ontario, 620, University-avenue, Toronto 2, Canada.

FOURTH NATIONAL POWER FARMING CONFERENCE.—Tuesday, Wednesday and Thursday, February 9, 10 and 11, 1954, in the Town Hall, Cheltenham. Organised by the *Power Farmer: Britain and Overseas*, Dorset House, Stamford-street, London, S.E.1. (Telephone: WATerloo 3333.)

34TH VIENNA SPRING TRADE FAIR.—Sunday, March 14, to Sunday March 21, 1954, at Vienna. Apply to the British-Austrian Chamber of Commerce, 29, Dorset-square, London, N.W.1. (Telephone: PADdington 7646.)

THIRD ELECTRICAL ENGINEERS' EXHIBITION.—Tuesday, March 16, to Saturday, March 20, 1954, at Earl's Court, London, S.W.5. Organised by the Association of Supervising Electrical Engineers, 54, Station-road, New Barnet, Hertfordshire. Apply to Mr. P. A. Thorogood, 35, Gibbs Green, Edgware, Middlesex. (Telephone: MILl Hill 3528.)

SECOND FACTORY EQUIPMENT EXHIBITION.—Monday, March 22, to Friday, March 26, 1954, at the two halls of the Royal Horticultural Society, in Vincent-square, and Greycoat-street, London, S.W.1. Apply to Mr. J. E. Holdsworth, 117, Kingsway, London, W.C.2. (Telephone: HOLborn 1414.) See also page 218, *ante*.

SYMPOSIUM ON MIX DESIGN AND QUALITY OF CONCRETE.—Tuesday, Wednesday and Thursday, April 6, 7 and 8, 1954, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Further particulars obtainable from the secretary, the Cement and Concrete Association, 52, Grosvenor-gardens, London, S.W.1. (Telephone: SLOane 5255.) See also page 108, *ante*.

CONFERENCE ON THE PHYSICS OF PARTICLE SIZE ANALYSIS.—Tuesday, April 6, to Friday, April 9, 1954, at Nottingham University. Organised by the Institute of Physics, 47, Belgrave-square, London, S.W.1. (Telephone: SLOane 9806.)

LIÉGE INTERNATIONAL FAIR.—Saturday, April 24, to Sunday, May 9, 1954, at Liége, Belgium. Apply to the manager, Foire Internationale de Liége, 17, Boulevard d'Avroy, Liége, Belgium. See also page 218, *ante*.

ROYAL SANITARY INSTITUTE HEALTH CONGRESS.—Tuesday, April 27, to Friday, April 30, 1954, at Scarborough. Apply to the secretary of the Institute, 90, Buckingham Palace-road, Westminster, London, S.W.1. (Telephone: SLOane 5134.)

BRITISH INDUSTRIES FAIR.—Monday, May 3 to Friday, May 14, 1954, at Earl's Court, London, S.W.5; Olympia, London, W.14; and Castle Bromwich, Birmingham. Particulars obtainable from the director, British Industries Fair, Board of Trade, Lacon House, Theobald's-road, London, W.C.1. (Telephone: CHAncery 4411); or from the general manager, British Industries Fair, 95, New-street, Birmingham, 2. (Telephone: Midland 5021.)

FOURTH GAUGE AND TOOL EXHIBITION.—Monday, May 17, to Friday, May 28, 1954, in the New Hall of the Royal Horticultural Society, Elverton-street, Westminster, London, S.W.1. Organised by the Gauge and Tool Makers' Association, Standbrook House, Old Bond-street, London, W.1. (Telephone: HYDe Park 3451.)

FOURTH MECHANICAL HANDLING EXHIBITION.—Wednesday, June 9, to Saturday, June 19, 1954, at Olympia, London, W.14. Organised by *Mechanical Handling*, Dorset House, Stamford-street, London, S.E.1. (Telephone: WATerloo 3333.)

CONFERENCE ON CIVIL ENGINEERING PROBLEMS IN THE COLONIES.—Monday, June 14, to Friday, June 18, 1954, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Apply to the secretary of the Institution at that address. (Telephone: WHItehall 4577.) See also page 87, *ante*.

FIRST INSTRUMENT CONGRESS AND EXPOSITION.—Tuesday, September 14, to Friday, September 24, 1954, in the Commercial Museum and Conference Hall, Philadelphia. Sponsored by the Instrument Society of America. Apply to the manager, Mr. Richard Rimbach, 921, Ridge-avenue, Pittsburgh 12, Pennsylvania, U.S.A.

ELECTRICAL AND RADIO EXPOSITION.—In October, 1954, at Melbourne, Australia. Organised by the Electrical and Radio Federation (Victoria), Dominion Chambers, 59, William-street, Melbourne, C.1.

LABOUR NOTES.

WORKPEOPLE throughout the country are being invited to co-operate as fully as possible in the activities of the local productivity committees set up at the instigation of the British Productivity Council. In an appeal for such support, Sir Vincent Tewson, the general secretary of the Trades Union Congress, gives an assurance that these committees will not encroach in any way on the functions of existing organisations, and asks employees generally to assist in raising the level of production throughout industry. Copies of Sir Vincent's statement have been sent by the Council to the chairmen of all local committees with a suggestion that they should ask firms in their areas to publish Sir Vincent's remarks in the firms' house journals. It is reported that some 70 local committees will have been set up, under the auspices of the Council, by the end of October. Arrangements are being made to hold conferences between representatives of the Council and chairmen of the committees on a regional basis during the winter months.

During the four-weekly period ended August 18, 1953, there was a decline by one point in the official cost-of-living figure. The index of retail prices recorded a level of 140 for all items on that date, compared with one of 141 for the period ended July 14. The fall in the index figure was due largely to reductions in the average prices of potatoes, apples, bacon, mutton and other foodstuffs, although these alterations were offset, to some extent, by increases in the prices of eggs, milk, home-killed beef, and fish. Increases in the cost of rail and road travelling, particularly in the London area, were also taken into account. The index measures the average changes, month by month, in the prices of goods and services which enter into working-class expenditure in the United Kingdom. It was commenced, in its present form, on June 17, 1947, the level of prices on that date being taken as 100.

Claims for an advance of 15 per cent. on wages, made on behalf of railway employees by the National Union of Railwaymen, the Associated Society of Locomotive Engineers and Firemen, and the Transport Salaried Staffs' Association, were rejected on September 15 by representatives of the Railway Executive. A similar claim, made on behalf of railway shopmen by the National Union of Railwaymen and the Confederation of Shipbuilding and Engineering Unions, was also rejected. Well over 500,000 employees are involved and it is stated that the increases, if granted in full, would add another 39,000,000*l.* to British Railways' annual wages bill. In the course of their reply to the claim the representatives of the Railway Executive pointed out that, in the present circumstances, an increase in wages would be reflected in still higher passenger fares and freight charges. The matter will now be placed before the Railway Staff National Council and may be submitted, eventually, to arbitration.

Claims for an increase in pay for all miners employed on a day-wage basis are expected to be presented to the National Coal Board in the near future. The executive committee of the National Union of Mineworkers decided at a meeting on September 17 to ask for an early meeting with the Board in order that a preliminary discussion on the wage situation may take place. More than 300,000 miners are likely to be affected by the proposed claims, which will apply to all grades, irrespective of existing maximum rates.

The court of inquiry set up by the Minister of Labour, Sir Walter Monckton, to investigate the labour dispute in the electrical-contracting industry, which led to a series of "guerrilla" strikes, commenced their sittings in public in London on September 17. Other members of the court, in addition to the chairman, Mr. John Cameron, Q.C., who is Dean of the Faculty of Advocates, are Sir Graham Cunningham, chairman of the shipbuilding advisory committee to the Admiralty and Ministry of Transport, and Mr. G. B. Thorneycroft, formerly secretary of the Transport Salaried Staffs' Association. The dispute arose owing to the rejection by the employers of a claim by the Electrical Trades Union for an increase of 3*d.* an hour for men employed in the London area and of 2½*d.* an hour for provincial operatives. It was reported on the day before the opening of the court that about 4,300 electricians had been taking part in strike action. Following the appointment of the court, the men were strongly recommended by the union to return to work.

Questioned by the chairman as to why the union, if it had a good case, could not agree to submit the dispute to arbitration, after the employers had expressed their willingness to accept the award of an arbitration tribunal, Mr. W. C. Stevens, the union's general secretary, expressed the view that, if his union had taken such a course after strike action had commenced, it would have represented unconditional surrender to the employers. Further, it would have been used against the union later in other negotiations and it would make it appear that arbitration had been possible earlier in the dispute. In his statement on behalf of the union, Mr. Stevens informed the court that two increases of 2*d.* an hour were granted during 1952 but that these were not considered sufficient to meet rises in the cost of living. Last March, the union presented a claim for a "substantial" increase in wages and this was rejected by the National Federated Electrical Association, on behalf of the employers, on June 10.

Later, the Association was informed that, unless an offer of an increase was received by August 24, strike action would be sanctioned. Neither side made suggestions that the dispute should be sent to arbitration but after strikes had commenced, meetings with a view to conciliation took place between the parties concerned, under the auspices of the Ministry of Labour. Mr. Stevens said that the union tried to show that increases of 3*d.* an hour in London and 2½*d.* in the provinces were justified on the ground of rises in living costs alone. The reply of the Association was that they would have to consult their 93 branches, and they rejected the suggestion of an interim offer. The request for a "substantial" increase had been made in the hope of obtaining a figure which could have been used as a basis for further negotiation or for acceptance. Mr. Stevens stated that the sites chosen for strike action had been selected solely because of their value to the union in the dispute and not because of their national importance.

On behalf of the Association, it was pointed out that places at which the strikes had occurred included sites which were of importance to the defence programme or the national economy, namely, atomic-energy establishments, oil refineries and factories. On the following day, Mr. L. C. Penwill, secretary and director of the Association, referred to former disputes with the union which had led to the suspension of the industry's negotiating machinery when it was considered by the Association that the union had made breaches in the national working rules. A campaign had been commenced in which the union expressed its strong objection to redundancy in the industry.

With respect to the present wage claim, Mr. Penwill denied that there had been any unnecessary delays by the Association. He said that he did not regard the earlier token strikes which had taken place as being due to spontaneous action by the men concerned, but as being inspired by the union. It was felt that the union was well aware of the alternatives which were open to it when the Association's reply to the claim was received. As far as his own committee was concerned, Mr. Penwill said, arbitration would have been seriously considered but for a feeling that the union had no desire for such a course. At the concluding public meeting of the court, which took place on Monday, final addresses were given on behalf of both sides. Mr. H. J. Phillimore, Q.C., for the employers, said that great damage had been done to the industry, which only time might heal. The court's findings will be published later.

APPLICATIONS OF SOLAR ENERGY.

Fig. 7.

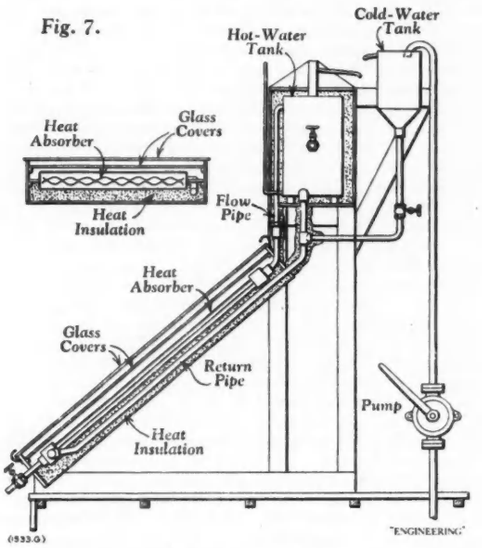


Fig. 8. (a)

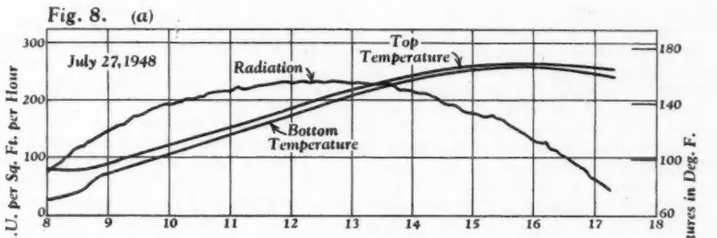
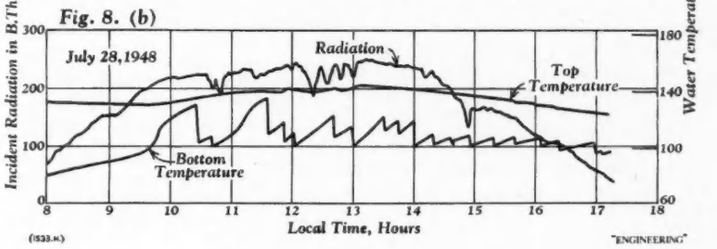


Fig. 8. (b)



SOLAR ENERGY: PAST, PRESENT AND FUTURE APPLICATIONS.*

By HAROLD HEYWOOD, D.Sc. (Eng.), Wh. Sch., M.I.Mech.E.

(*Concluded from page* 380.)

PRESENT RESEARCH POSITION.

DURING the period between the two World Wars, little progress was made in the development of solar-energy utilisation. In 1940, however, there was a definite stimulus in the Godfrey L. Cabot bequest to the Massachusetts Institute of Technology for research on this subject. Professor H. C. Hottel is chairman of the project and much of the research has been conducted by Dr. Maria Telkes. An examination has been made of four possible lines of research, namely, the collection of solar energy as heat,[14] and the fields of photo-chemistry, photo-electricity and thermo-electricity. In this last field, new alloys have been developed for use as thermo-elements, and there are indications that, with these, an efficiency exceeding 6 per cent. may be attainable in the direct conversion of radiant energy to electricity.[15] Another development has been the construction of a solar house in which the heat collected during the day is stored and used later to heat the building at night.[16] Storage is effected by utilising the latent heat of fusion of crystalline sodium sulphate at a temperature of 90 deg. F. The heat capacity of such a system is about eight times greater than that of a similar volume of water.

Professor F. A. Brooks, of the University of California, has investigated the efficiency of solar water heaters for domestic purposes,[17] many thousands of these now being in operation in the southern parts of the United States. Flat-plate heat absorbers are used for this purpose, and provide a simple but effective means of heating water to at least 140 deg. F. in localities where clear skies are frequent even in the winter season. The heat absorber is usually mounted on the roof of the house or a veranda, and is fixed in position. The heater forms part of the thermo-siphon system, in which the hot water is collected in a storage tank, and may, of course, be linked with the hot-water supply system of the house, an auxiliary fuel heater being provided for use in cloudy periods.

At the other end of the scale of working temperatures, Dr. Felix Trombe, of Paris, has been investigating the production of very high temperatures, even up to 3,000 deg. C.[18] This has been accomplished by a high degree of concentration with spherical mirrors, as shown diagrammatically in Fig. 5 (*h*), on page 379, *ante*, and the object has been to melt metals and refractory oxides, or to promote gaseous reactions at high temperatures.

Dr. Ghai, Assistant Director of the National Physical Laboratory of India, is investigating the possibilities of solar heat for cooking, on which the first paper has been published recently.[19] There is undoubtedly a very wide field of application in this connection, particularly in areas that are short of solid fuel that could be used for cooking.

Brief descriptions have been given in the technical Press of solar-energy plants that have been constructed in Soviet Russia, both for water heating, water distillation and for power production. The reports are insufficiently detailed, however, to enable the precise outputs to be determined and compared with other processes.

A report by the National Physical Laboratory Committee on Utilisation of Solar Energy was issued in 1952[20], and summarised the information then available regarding current research. Sections of the report dealt with the available solar energy, and its applications for heating, cooking, refrigeration, water distillation and power generation, all of which have already been discussed in the preceding sections of this paper. A considerable portion of the report was devoted to the production of vegetable fuel by natural growth, and particularly whether the rate of such growth could be increased artificially.

It is generally agreed that the efficiency with which solar radiation is converted to fixed carbon does not exceed 2 per cent., this figure being based on the radiation received by the leaf surface. The efficiency based on ground area is very much less, being only a small fraction of 1 per cent. If this figure is multiplied by the efficiency of conversion to mechanical power, which would not exceed 5 per cent. in small units, then it is clear that only in localities where vegetation naturally grows at a rapid rate could this be regarded as a suitable source of power. It has been suggested that the efficiency of photo-synthesis is greatest for algæ cultivated in glass-covered tanks with CO_2 enrichment of the atmosphere, but the report shows that such artificial cultivation is impracticable for the purpose of power production. Since many localities subjected to intense solar radiation are arid and unsuitable for intense cultivation of vegetable growth, it is the opinion of the writer that cultivation cannot provide fuel for power or heating with an efficiency that is comparable with other means of using the solar radiation directly.

TABLE VI.—HEAT COLLECTION AND EFFICIENCY.

(All figures are per sq. ft. of absorber area and for the period 8 to 16 hours.)

1948.	H_t B.Th.U.	E_i B.Th.U.	Efficiency, $\frac{H_t}{E_i}$ Per Cent.	Water Temperatures, Deg. F.		Output, Lb. of Water.
				Inlet.	Final.	
July 27	880	1,490	59	84	170	10·2
July 28	1,072	1,566	68	84	137	20·2

TABLE VII.—HEAT COLLECTION DATA.

(All figures apply to period 8 to 16 hours, and show averages for all days, "effective days,"* and maximum values.)

Month in 1949.	Number of Days.	B.Th.U. Per Square Foot.	Maximum Temperature, Deg. F.	Efficiency of Collection, Per Cent.	Air Temperature, Deg. F.	Bright Sun, Hours.
All days—						
March	31	294	85	47	45	2·8
April†	30	575	123	48	56	5·0
May	31	577	124	52	58	4·7
June	30	611	131	54	66	4·5
"*Effective days*"—						
March	12	477	105	43	47	5·8
April†	22	704	135	48	58	6·2
May	23	678	132	56	59	5·4
June	20	774	145	56	68	6·0
Maximum—						
March	1	784	133	55	52	8·0
April	1	908	145	57	66	7·2
May	1	918	152	50	54	8·0
June	1	1,005	170	50	68	8·0

* An "effective" day is when bright sun period exceeds four hours.
† Radiation during April, 1949, was exceptionally high.

* Paper read before Section G of the British Association at Liverpool, on Friday, September 4, 1953.

RESEARCH AT THE IMPERIAL COLLEGE.

At Imperial College, London, experimental studies commenced in 1947, and have been continued by students on various aspects of the utilisation of solar energy. The first series of experiments were made on a flat-plate absorber, one foot square, covered on the front surface by plates of glass, and protected by heat insulation on the back surface. The heat collected was absorbed by means of water channels soldered on the back surface of the copper plate, through which water was circulated under constant head and the temperature rise measured. In this way the rate of heat absorption was determined for various numbers of glass plates and for various temperatures of collection. The series of curves for heat collection against temperature, such as have been described earlier and shown in Fig. 4, were obtained from this equipment.[21]

Radiometers were constructed to record continuously the solar intensity, and the design was based on the standard Moll thermopile, though larger in size. These radiometers were calibrated by comparison with standard instruments at Kew Observatory, and the thermo-electric output could be shown on an indicator or recorded on a clock-driven drum. Concurrently with these researches on the fundamental principles of heat collection, a water heater of 10 sq. ft. area was installed at the writer's residence at Sidcup, 10 miles S.E. of London. The installation was intended to be of temporary nature, but has been in operation for four years. The absorber was constructed from two sheets of corrugated galvanised iron placed in "mirror image" position so that eight water channels were formed along the length of the absorber. The edges were riveted and soldered, and square-section headers fitted at the top and bottom edges. The metal absorber with blackened front surface was enclosed in a wooden casing with heat insulation at the back and with two layers of glass over the front. A hot-water storage tank was placed at a level slightly higher than the top of the absorber, with flow and return pipes, so that the whole formed a thermo-syphon circulating system. The water capacity of the absorber was 5 gallons and the storage tank was also of 5 gallons capacity, so that the total water capacity was 10 lb. per square foot of absorber surface. The general arrangement is shown in Fig. 7, on page 409; the cost of this section of the research was covered by a grant from the Central Research Fund of the University of London.

Output tests were made during the summer of 1948, the water flow and rate of heating being related to the incident radiant energy. A three-point recorder enabled simultaneous readings to be taken of the maximum and minimum water temperatures in the system and the output from the thermo-pile radiometer. There are various ways of operating such an absorber system. One method is to allow the water to circulate naturally for the whole day without the withdrawal of any water, the total heat input being determined. This is not, however, the most effective way of collecting heat, for although during the morning increasing radiation intensity corresponds with rising water temperature, after noon the radiation decreases while the water temperature is still increasing. Hence the water reaches a maximum temperature at about 15 hours, though the radiation intensity may still be appreciable. A more effective method of operating the absorber is to withdraw the water as soon as it is hot enough for the purpose required, and replace it by cold water. In this way the mean temperature of the system can be reduced in the afternoon and an effective heat recovery obtained. In practice, the withdrawal of hot water could be controlled automatically by means of a thermostat. Typical records obtained during tests as described above are shown in Fig. 8 (*a*) and (*b*), the former showing the results obtained with no water flow and the latter with the water flow adjusted to maintain an approximately constant outlet temperature. The results of the tests on two days in July, 1948, are given in Table VI, on page 409.

Daily records of the heat collected were kept during the spring and early summer of 1949. On most days the system was left undisturbed, and the total gain in heat measured over the period 8 to 16 hours local time. The results of these tests, which apply to a water capacity of 10 lb. per square foot, were averaged for each month and are shown in Table VII.

The averages for all days are somewhat low, but if effective days are selected then the yield is quite satisfactory. A day is considered "effective" if the bright sunshine period exceeds approximately four hours, and this method of selection gives an indication of the yield that could be expected continuously in more favourable climates. With a reduced water capacity of 5 lb. per square foot, the temperature rise is increased, though the heat collected is no greater and may even be slightly less. With this reduced capacity the water may be brought to the boiling point, and on several days the maximum temperature was held at 212 deg. F. for a period of two hours. When the absorber was emptied by draining, the maximum temperature attained was 300 deg. F.

Another series of experiments was concerned with concentration by means of plane mirrors placed at the side of the absorbing surface. The arrangement is somewhat similar to the Tacony absorber of Shuman, shown in Fig. 5 (*e*), but with the mirrors placed at all four sides of the square absorber plate.[22] The shape thus resembled somewhat a square funnel and it was found later that the solar cooker designed by Adams in 1876 was of the same type, but with an octagonal base and eight mirrors forming the sides. The geometry of this system is interesting, and it can be shown that the maximum practical concentration is obtained when the length of the mirrors is three times the side of the square absorber plate. The equilibrium temperature with this arrangement was considerably above the normal boiling point of water, but the mistake was made of using back-silvered mirrors, resulting in considerable absorption by the glass. With surface-silvered mirrors it was estimated that an efficiency of 50 per cent. would be attained at 170 deg. F. This arrangement has the advantage that it is less sensitive to the accuracy of alignment than parabolic reflectors, and an error in direction of 10 deg. makes very little difference to the heat collected.

Other experiments were made with spherical mirrors, using 36-in. diameter searchlight mirrors.[23] These experiments were of an exploratory character, but showed that an efficiency of 50 per cent. could be obtained at a temperature of 300 deg. F. There would thus be no difficulty in generating steam at a useful pressure by such means. Research work is being continued on various aspects of solar-energy utilisation, and data are being collected which will be of great value in the subsequent design of larger operating units.

FUTURE POSSIBILITIES OF SOLAR-ENERGY APPLICATIONS.

The various forms of equipment for the direct utilisation of solar energy that have been described in a preceding section were more or less successful technically, but failed economically. This failure may be ascribed to the following causes: the relatively high cost of the equipment; the low yield obtained; and the low cost and ready availability of more convenient fuels such as coal and oil. The present tendency, as is well enough known, is for fuels to become more expensive, a tendency which is most unlikely to change for the better. At the same time, methods of fabrication are improving, new materials are becoming available both for construction of equipment and for use as working fluids or heat-transfer media, and there is an increasing knowledge of thermodynamic processes. Hence it would seem that the economic balance will change favourably towards the direct utilisation of solar energy, though only in suitable locations can any substantial progress be anticipated.

Though it is hazardous to prophecy, an attempt will be made to forecast the future prospects of solar-energy utilisation in the various fields. In general, one can say that there is little prospect of using solar energy on a large scale in cities or towns where the population density is high and alternative sources of energy are "on tap," even though they may be expensive. The problem of intermittency and of the night period is sufficient in itself to make effective use of solar energy impossible in such circumstances. The field of application is essentially limited to rural or sparsely populated districts, where land space is cheap and where other energy sources are lacking. Such areas, however, total in the aggregate a large proportion of the habitable surface of the earth, and comprise a considerable, though often unconsidered, proportion of the world's inhabitants. There are many fields of application of solar energy where improvements in the amenities of life could be effected by the use of solar energy. The primary problem is not so much one of developing new processes, but is one of design to produce simple equipment at minimum capital expense.

Utilisation as Low-Grade Heat.—This field is the one that may be considered solved at the moment, for there are many designs of absorber which are simple and reasonably efficient. The heat may be used as domestic hot water, for space heating or for cooking. In semi-tropical countries the heat stored in the day may be used at night for house warming. Seasonal storage of heat, i.e., from the summer to the winter period, presents considerable constructional problems. It would be difficult to store the heat collected during the summer at a temperature sufficiently high for direct use in the winter, but it would be more feasible to store the heat in a large water reservoir at a few degrees above atmospheric temperature and to use this as an energy source for a heat-pump system. Such a scheme would collect the radiant energy at a high efficiency with relatively small thermal losses and would enable the advantage or performance efficiency ratio of the heat pump to be increased considerably.

The production of potable water by distillation is another application with definite possibilities in tropical countries. The simplest equipment consisting of glass-covered tanks would yield only about 0·5 lb. of water per square foot per day, but improvements in design would increase this to 1 lb. or even 2 lb. per square foot per day, which is the maximum for direct evaporation. It has been suggested, however, that on some of the islands near Aden a combination of wind-driven thermal pump with heat collector would give a very much larger yield. There may also be scope for increasing the yield of salt by concentration in open salterns or pans, and this is under investigation in Ceylon by a former research student at the Imperial College.[24]

Power Generation.—This is a problem that is more difficult to solve, though small power units of 5 kW to 10 kW would fulfill a great need in many localities, particularly for pumping water for irrigation. Low-temperature absorbers are simple but the thermodynamic efficiency of conversion of heat to mechanical energy is low. The conversion efficiency increases with higher temperatures, but the absorbers become more complex and expensive. This dilemma is linked with the choice of working fluid and type of prime mover, i.e., reciprocating engine or turbine.

If it is assumed that an engine can attain half of the Carnot efficiency for the cycle, i.e., $\frac{(T_1 - T_2)}{T_1}$ where T_1 is the upper temperature and T_2 the lower temperature, then the probable overall efficiencies based on incident radiation may be calculated for various absorber temperatures. The effect is shown by the curves in Fig. 9, which have been calculated for a flat-plate absorber (concentration unity), and for an absorber with mirror concentration of 10 to 1. The probable overall efficiency, which is one-half of the product of the Carnot efficiency and the absorber efficiency, is zero when either the Carnot or the absorber efficiencies become zero, i.e., when the temperature rise is very small, or at the equilibrium temperature, respectively. At a certain intermediate temperature the product of the efficiencies is a maximum, and this defines the optimum temperature of operation for a particular degree of concentration. The Carnot efficiency is quite independent of the working fluid used, but in practical applications the characteristics of the working fluid are very important and influence the choice for a particular range of working temperatures. While steam has many advantages as a working fluid, full advantage of the low-temperature end of the cycle cannot be obtained by the reciprocating engine. The turbine is capable of utilising effectively steam at low

pressure, but against this is the fact that small turbines are inefficient. A working fluid that is more volatile than water would mean that a small but efficient reciprocating engine could be used for power generation, but the working fluid would need to be heated indirectly by water passed through the absorber.

Now the curves in Fig. 9 show that higher efficiencies are obtainable with mirror concentration of the radiation on the absorber, but solar energy utilisation differs from normal heat-engine operation in that the energy costs nothing, and that it is the construction of the equipment and the value of land space that represent the cost of utilisation. Thus, it might be that a very simple form of fixed flat-plate absorber, though occupying greater space than a mirror absorber, would be the more economical to construct. In any case, as much use as possible should be made of fixed absorbing surfaces for the preliminary heating and evaporation of the working fluid, with perhaps a small area of mirrors for superheating the vapour. One possible design which could use the refrigerating fluid Freon 12 is shown diagrammatically in Fig. 10. The flat-plate absorber which supplies the major portion of the heat is filled with water and the heat subsequently transferred to evaporate liquid Freon. The Freon vapour is superheated in a mirror concentration absorber and then passed to a small high-speed reciprocating engine. After condensation, the vapour is returned to the Freon boiler.

An alternative working fluid having many advantages is air, and a constant-pressure gas-turbine cycle though workable would only be efficient in large powers. A new form of hot-air engine has been developed by Dr. T. Finkelstein in conjunction with the writer,[25] and this is specially intended to operate at relatively low temperatures. Thus, there are many ways in which power units could be operated directly by means of solar radiation. Which will prove to be economic, and how distant in the future, depend upon further research and development in design.

Refrigeration and Air Conditioning.—A cooling effect is the ideal load in tropical countries, for the requirement would be a maximum when solar radiation was greatest. The load could take the form of low-temperature freezing for food preservation or more moderate temperatures for air cooling. The ammonia-absorption cycle would probably be the most suitable for refrigeration, the pressure range being modified to suit the heating temperature most convenient. The problem of operation in the day period only could be overcome by increasing the heat-absorbing area either to give a storage of heat which would continue to operate the refrigerator during the night, or a storage of "cold" sufficient to maintain a low temperature in the cooling chamber.

Air cooling could be effected by the lithium-bromide-water vapour absorption system, in which the diluted lithium-bromide solution would be re-concentrated in the solar heater. As an alternative, the air could be cooled directly by expansion, and turbine machines would be most effective if these were efficient in small sizes. An arrangement is shown diagrammatically in Fig. 11. A compressor is driven by two turbines, a power unit and an expansion unit. A fraction of the air from the compressor C passes through the solar heater and then to the power-unit turbine T; the remainder of the air, after cooling to atmospheric temperature, passes to the expansion-unit turbine E M, doing work and being rejected at a temperature below atmospheric. The higher the temperature attained in the solar heater, the smaller the fraction of the compressed air which passes through this part of the circuit, and consequently the greater the coefficient of performance for the system as a whole. The special hot-air engine mentioned in the preceding section has been designed to be reversible and a similar system to the above could be operated by an engine unit driving a cooling unit. From a study of the literature, little research appears to have been conducted on this aspect of the utilisation of solar energy, yet the field is a most promising one.

Conclusions.

The possibilities of using solar energy must be examined impartially against the background of future developments in the fuel-supply situation, and the present economics must not be stressed too greatly. Over optimism is as great a danger as undue pessimism, for it is clear that applications in the near future are limited, though the potential applications are significant. It is evident that solar-energy utilisation has no prospect of success in large communities, but in isolated areas with semi-tropical climates there are many fields of application ready for development. As fuels become more scarce and costly so will the economic balance become more favourable, and experience gained now may prove of the greatest value in the future. Many of the possibilities which have been described in the paper involve no new principles, but success is dependent upon careful design and the introduction of new materials of construction as these become available.

Fig. 9.

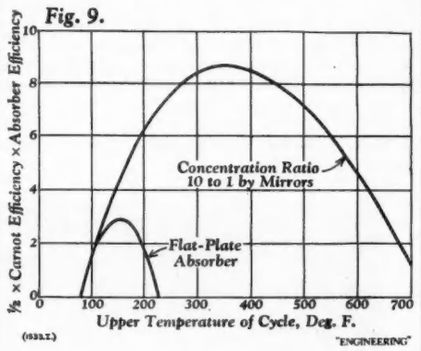


Fig. 10.

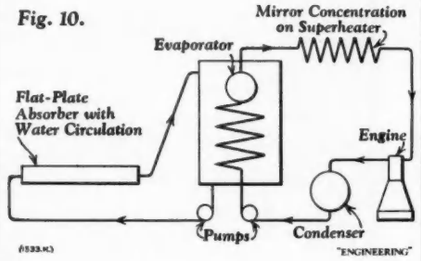
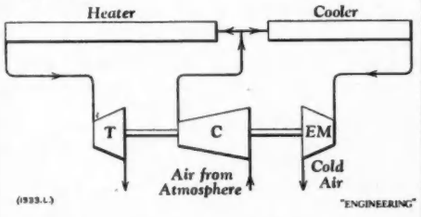


Fig. 11.



Research on solar-energy utilisation ranges over many fields of science: solar physics, meteorology, the physics of heat transfer, thermodynamics, thermoelectricity, plant growth and chemical synthesis. Once an interest in the subject has been roused, few will relinquish the hope of achieving an objective that could benefit many peoples in countries at present only partly developed, and would enable "two ears of corn, or two blades of grass, to grow upon a spot of ground where only one grew before."[26]

Appendix I.

Data on Solar Energy and Concentration Factors.

1 cal. per sq. cm. per minute = 221·2 B.Th.U. per sq. ft. per hour = 698 watts per sq. metre.

1 cal. per sq. cm. per day = 3·687 B.Th.U. per sq. ft. per day = 0·485 watt per sq. metre.

Solar Constant.—1·94 cals. per sq. cm. per min. =429 B.Th.U. per sq. ft. per hour = 1,354 watts per sq. metre.

The fraction of the total radiation from the sun intercepted by the earth is the ratio of the projected area of the earth to the area of an imaginary sphere of radius equal to the mean distance of the earth to the sun. Taking the radius of the earth as 3,960 miles and the mean distance to the sun as 93×10^6 miles, this ratio becomes $1 : 2{\cdot}21 \times 10^9$.

The total energy intercepted by the earth in 24 hours at a rate of 430 B.Th.U. per square foot per hour is $14{\cdot}2 \times 10^{16}$ B.Th.U. The world reserves of coal and lignite are estimated as being equivalent to 6×10^{12} tons of bituminous coal (A. Parker, World Energy Resources and their Utilisation. *Proc. I. Mech.E.*, vol. 160, page 441 (1949).) Assuming a calorific value of 14,000 B.Th.U. per lb., the heat equivalent of these reserves is $188{\cdot}2 \times 10^{15}$ B.Th.U. Therefore the number of days for the solar radiation to equal the heat equivalent of the world's coal resources is 13¼.

Concentration of Energy in Coal Formation.—The mean radiation intensity on a horizontal surface under semi-tropical conditions may be taken as 1,500 B.Th.U. per square foot per day. A good yield of vegetation is of the order of 6 tons per acre per year, and assuming a calorific value of 1,800 B.Th.U. per lb., the heat equivalent is 1·52 B.Th.U. per square foot per day. This represents a concentration of approximately 1,000 to 1, or an efficiency of energy fixation of 0·1 per cent. It is difficult to estimate the weight of vegetation required to form one pound of coal, but the ratio of incident solar radiation to heat in coal formed is unlikely to be less than 6,000 to 1.

Concentration of Energy in the Form of Elevated Water Supply.—The mean daily evaporation over the Atlantic Ocean may be assumed to be 0·1 in. of water, say 36 in. per annum, and the mean annual rainfall on the West Coast of Scotland is approximately 100 in. This represents a concentration of approximately 3 to 1. If a lake has an area of 10 square miles, and the watershed has an area of 350 square miles, then the concentration in terms of area ratio from ocean to lake, is of the order of 100 to 1. The thermal efficiency of transportation, however, is very low. The latent heat of steam at 60 deg. F. is 1,060 B.Th.U. per lb. = 825,000 ft.-lb. per lb., and adding the potential energy to raise the vapour to a height of 5,000 ft. gives an energy input of 830,000 ft.-lb. per lb. If the head of water available from the lake for power generation is 500 ft., then the efficiency of transportation is as 1 is to 1,660.

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[25] Finkelstein, T., University of London Thesis, Ph.D., 1953.

[26] Swift, Jonathan, *Voyage to Brobdingnag*, Chapter 7 (1726). The full quotation is: "And he gave it for his opinion, that whoever could make two ears of corn, or two blades of grass, to grow upon a spot of ground, where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together."

Symposium on Cathodic Protection.—The Society of Chemical Industry, Corrosion Group, are organising a symposium on "Cathodic Protection," to be held at the Institution of Electrical Engineers, Savoy-place, London, W.C.2, on Friday, November 13, from 9.45 a.m. until 5.30 p.m. Seven papers will be presented, embodying experience gained in various parts of the world with the protection of ships, underground pipes, storage tanks and other structures used in contact with water or soil. It is understood that preprints of the papers will be available before the meeting and details of them will be announced shortly by the Society.

RADIOACTIVE CONTAMINATION OF WATER SUPPLIES.

IN our issue of May 15 this year (page 618) we referred briefly to the effect of the atomic-energy industry on water supplies, and reproduced a portion of a paper by Mr. A. Wolman, of Johns Hopkins University, Baltimore, and consultant to the United States Atomic Energy Commission, and by Mr. A. E. Gorman, also of the Commission. The Ministry of Housing and Local Government have now issued a memorandum addressed to all water undertakings, county councils, county borough councils (who are not water undertakers) and River Boards, on the subject of war-time contamination of public water supplies by radioactive substances. This memorandum is to be followed by one dealing with the scientific considerations and the use of instruments designed for field use for measuring concentrations of radioactivity. Meanwhile it has been decided that, in time of war, it will be for the Regional Commissioner to decide whether water supplies, which have become contaminated to such a degree as to render them dangerous to health, should be cut off at source or be permitted to continue. In the latter case it will be for him to decide what steps should be taken to ensure that the supply mains are used only for the supply of non-potable water. At the same time, it will be the responsibility of the water-supply undertakings to afford such piped supplies as prove to be feasible for potable and non-potable purposes, and, if piped potable supplies are not possible, to provide temporary potable supplies either by water-tanker or from some other uncontaminated source, until such time as the contaminating radioactivity has decayed sufficiently to render an original source of supply again fit for drinking and cooking purposes.

THE BALA LAKE IMPROVEMENT SCHEME.

THE Bala Lake Improvement Scheme represents a comprehensive attempt on the part of the responsible authority—the Dee and Clwyd River Board—to reduce serious flooding of the River Dee, which occurs every year, and for storing surplus water for use by water boards in the more thickly populated areas which draw their supplies from the lake. The River Dee flows from Bala Lake in the Aran Mountains in North Wales; it passes through the town of Bala, to be joined by the River Tryweryn a further half-mile downstream before reaching the successive areas of Corwen, Llangollen, Wrexham and Chester. The scheme provides for temporary and permanent diversions of both the Dee and Tryweryn, which for a time will involve reversing the flow of the rivers; the construction of a bridge over the new channel of the Dee; the dredging of a channel in the lake; the provision of new sluices; the construction of three weirs across the diverted Tryweryn; the construction of a gauging station below the confluence of the two rivers; and dredging the river bed for two miles farther downstream to eliminate existing rapids and form a more even river bed. The consulting engineers are Messrs. Binnie, Deacon and Gourley, 57, Victoria-street, London, S.W.1, and the contractors are John Laing and Son, Limited, from whose news-sheet *Team Spirit* this information is taken.

The work will result in the weirs across the Tryweryn diverting part of the flood waters of that river into Bala Lake; the discharge from the lake will be controlled by sluices working in the new outfall channel, which will permit the lake to be drawn down some 6 ft. below its present level. At the onset of heavy rain, the lake can be drawn down to accommodate the Tryweryn floods so that the peak discharge in the Dee, downstream of the works, will be reduced to about half its former volume. During the summer, the waters of the Tryweryn, and of the other tributaries entering the lake, will be stored to augment the supplies in the lower Dee at the end of long dry periods, so ensuring water supplies to the population who draw on the river for both domestic and industrial purposes. The effect of substantially reducing flooding of the river is expected to be of far-reaching value in the Dee valley.

Progress has already been made in straightening and dredging the Dee for about one mile at the lower reaches of the scheme. The total excavation is expected to be about a quarter of a million cubic yards and some 20,000 cubic yards of stone will be used for pitching the river banks of the new channels. The excavation for the gauging station has been completed; the sides and bottom of the river have been lined with reinforced concrete and preparations are well in hand for the construction of the throated flumes. Access for plant and lorries to the site of the station has been obtained by tipping a chesil ford across the original river course.

Work has also been commenced on the construction of the foundations for the new bridge at the point where the Dee will flow from the lake. It is to be a five-span bridge in reinforced concrete with a masonry facing. Protection for the site during winter has been ensured by building a temporary dam across what will be the new channel for the river. Generally speaking, however, it is not expected that a great deal of progress will be made during the approaching winter months but it is intended that the greater part of the contract shall be completed during the fair-weather period of 1954, when the work on the sluices and weirs will be undertaken.

THE WELSH INDUSTRIES FAIR.

THE Welsh Industries Fair was opened in the Sophia Gardens Pavilion, Cardiff, on Wednesday, September 9, by Mr. A. G. B. Owen, O.B.E., chairman of the Owen Organisation, and was closed on Saturday, September 19. The Fair, which is an annual event, is organised by the National Industrial Development Council of Wales and Monmouthshire and endeavours to present a general view of the considerable variety of industries now carried on in the Principality; though it is somewhat hampered in so doing by the lack of a hall large enough for the purpose. This is undoubtedly the reason for the absence from the present Fair of many engineering firms who, in recent years, have opened factories in South Wales on the various trading estates and elsewhere; and for the fact that, for example, the steel industry is represented by a single stand, that of the British Iron and Steel Federation. From the point of view of the general public, it is probably satisfactory enough that the majority of the exhibits are of consumer goods, but, from the technical standpoint, it is to be regretted that engineering manufactures, which are now suth an important feature of Welsh industrial economics, are not more strongly in evidence.

There are, of course, various exhibitors of engineering components, notably the firms who form the Owen Organisation—Messrs. E. Camelinat and Company, Limited, Blast Engine House Works, Dowlais, Glamorgan, who are makers of pressings, spinnings, sheet-metal fabrications, etc.; Conveyancer Fork Trucks, Limited, Liverpool-road, Warrington, who exhibit the adaptation of their Diesel-engined truck for furnace-charging, illustrated above; Easiclene Porcelain-Enamel (1938), Limited, Darlaston, who display an electric washing machine and a refrigerator; Nuts and Bolts (Darlaston), Limited, Tredegar Works, Bridge-street, Tredegar, Monmouthshire, whose activities are indicated by their title; and Messrs. Rubery, Owen and Company, Limited, Whitegate Works, Wrexham, makers of steel shelving, lockers, nuts and bolts, etc.

The Conveyancer charging machine, referred to above, is the makers' TC6 model, which has a lifting capacity of 6,000 lb., and a vertical lift of 12 ft. or 14 ft. as a fork-lift truck; but in place of the fork-lifting gear (which can be readily substituted if desired) it has a hydraulically-actuated manipulator attachment for handling billets. The design was developed in collaboration with the English Steel Corporation. The four-cylinder Diesel engine, which has an output of 40 brake horse-power at 2,000 r.p.m., drives through a torque converter, so that no gear-changing is involved. The manipulator consists of a pair of detachable tongs, mounted on two steel arms pivoted centrally at their rear ends, and connected to the ram of a double-acting hydraulic jack, encased in a steel housing. The jaws of the tongs may be of several patterns, according to the shape of the material to be handled. The power for the manipulator is taken from the hydraulic system of the truck, the connections being by Exactor quick-release couplings, which enable the attachment to be removed in less than ten minutes. The firm also showed one of their smaller Conveyancer trucks, with a lifting capacity of 2,000 lb.; this model is battery-operated.

Among other exhibits may be mentioned several types of foam-making equipment for extinguishing fires, shown by the Pyrene Company, Limited, of 6, Grosvenor-gardens, London, S.W.1, who have a factory in South Wales at Maerdy-road, Ferndale; various types of abrasive sheet and belting for sanding machines, etc., exhibited by the Minnesota Mining and Manufacturing Company, Limited, of Penllergaer, Gorseinon, Swansea; a wide range of electrical fittings, fluorescent tubes, etc., shown by Thorn Electrical Industries, Limited, whose South Wales factory is at Cyfarthfa, Merthyr Tydfil; precast concrete units for light building construction, made by Woolaway Constructions, Limited, Lanelay Works, Pontyclun, Glamorgan; and a wide range of worm-gear speed-reducers, shown by Messrs. Fred Gilbert (Cardiff), Limited, of Canal-parade, Cardiff. Also shown on the stand of Messrs. Gilbert, who are makers of special-purpose machinery for various trades, was a quarter-scale model of a machine for rolling corrugated roof sheets, which they are constructing for export to Canada.

ULTRASONIC DETECTOR FOR FLAWS IN RAILS: ADDENDUM.—On page 11, *ante*, a description was given of an "Audigage" which is used by London Transport Executive for the detection of flaws in rails. This instrument was supplied to the Executive by the Equipment and Engineering Co., Ltd., 2 and 3, Norfolk-street, Strand, London, W.C.2.

ELECTRONICS IN THE SWITCHING OF TELEPHONE CALLS.*

By L. J. MURRAY, B.Eng. (Hons.), A.M.I.E.E.

TELEPHONE service requires the connection of one subscriber to another over a satisfactory both-way speech path. Electronic means have long since solved the problem of transmitting speech with adequate volume and clarity over lines of any length; what concerns us here is the problem of selecting and setting-up the path to be used between any given pair of subscribers. This process is known as switching. One subscriber may potentially require connection to any other in the world. Thus the problem is that of selecting any one of the world's 75 million working telephones and establishing a satisfactory speech path between it and the calling telephone. The majority of telephone calls are now handled by dialling or automatic switching. The proportion so handled will increase, and a subscriber will, in due course, be able to dial for himself at least any call in his own country, although some of the more complicated international calls may still require the attention of an operator. It is impracticable to gather together in one place the terminations of all the subscribers' telephone lines in a country, or even in a large town, for access by a calling subscriber. Hence it is necessary to establish intermediate switching points or exchanges through which the connection is extended. The switching equipment in these exchanges includes not only the actual contacts which are closed to extend the connection, but also the equipment which selects these contacts, closes them and keeps them closed until the subscribers have finished their conversation.

Fig. 1.

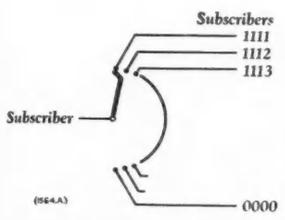
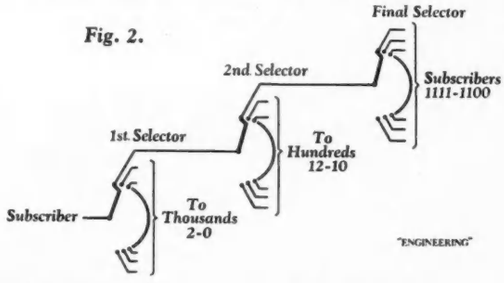


Fig. 2.



This may be illustrated by reference to the familiar manual telephone switching system, in which the operator learns that a subscriber wishes to call by means of a lamp signal. She answers by placing one of two plugs connected by a cord circuit into a switchboard jack connected with the subscriber's line and on ascertaining the number required completes the connection by placing the second plug into another switchboard jack connected to the called subscriber's telephone. When the connection is set-up she disconnects her own telephone circuit from it and can leave it and attend to the setting-up of other calls by means of other cord-circuits and plugs. Meanwhile the circuit between the two telephones is maintained until the operator disconnects it by taking out the plugs on receiving clearing (lamp) signals from the subscribers.

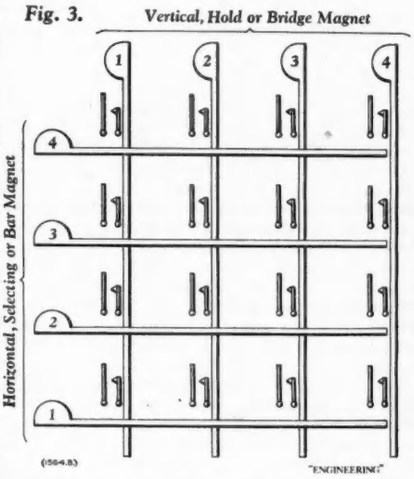
There are thus two distinct parts of the exchange or switching equipment. The talking circuit consists of the subscriber's lines, the switchboard jacks, the plugs and the cord circuit and cannot change its state without the assistance of the control equipment represented by the operator and her telephone circuit.

It is useful here to list the functions performed by the control equipment of an exchange :—

(1) Connection of the calling line to the exchange equipment to order the call, i.e., to send the called number.
(2) Receipt by the exchange equipment of the order.
(3) Selection and setting-up of the route which the connection will take.
(4) Signalling, which includes the notifying of the caller of the stage-by-stage progress of his call by dial tone and ringing, busy, or number-unobtainable tone; also the ringing of the called subscriber's bell. In calls requiring connections through one or more intermediate exchanges signalling also includes the passing of selection information from exchange to exchange. Where the connection is supervised by an operator, signalling includes the passing of calling and clearing signals to her.
(5) Registration of the call fee.
(6) Holding of the connection.
(7) Release of the connection on the receipt of clearing signals.

In the Strowger or step-by-step system used for automatic switching in this country, the talking circuit is made over paths formed by the setting of a movable wiper on one of a bank of contacts. The wipers are moved to the appropriate position by ratchet and pawl mechanisms controlled by electromagnets responsive to impulses generated by the subscriber's dial. Several other systems are in use throughout the world involving wipers and bank contacts brought into engagement by electro-mechanical switches of various types. In other systems, such as those using crossbar switches, the talking circuit is made through contacts of the relay type, i.e., in which precious-metal contacts are pushed into engagement by the operation of selected electromagnets. In all these systems the setting-up of the connection is controlled by the sequential operation of electromagnetic relays, which are themselves ultimately controlled by the impulses generated by the subscriber's dial, or an operator's dial or keysender.

Fig. 3.



Electronic devices have been used for isolated functions in telephone switching equipment but the use of the terms "electronic switching" or "electronic control of switching" can only be justified if either the talking connection itself, or the control equipment, or both, are substantially electronic.

Electronic Speech Paths.—Let us examine, first, the application of electronics to the talking connection. This can be done by the direct replacement of the electro-mechanical switch wipers and bank-contacts by triggered electronic devices, such as thermionic tubes, cold-cathode tubes, transistors, rectifiers, etc. In these the engagement of a wiper with a bank contact, or the closing of a relay-type contact, is represented by the rapid change of the electronic device from a non-conducting to a conducting state. Neither wiper and bank contacts nor relay-type contacts attenuate or distort speech frequencies, and while wiper and bank contacts may introduce slight microphonic noise into a connection, relay-type contacts normally do so to a negligible degree. With electronic devices, however, there is a much greater liability to attenuation, distortion and noise. This does not necessarily rule out the use of such devices. Cold-cathode tubes, for example, can be used as contacts in the speech path with suitable design of circuits to compensate for any attenuation or distortion introduced by the tube itself; while development now in progress seems to indicate that the inherent noise level can be reduced to negligible proportions by tube design. It would appear, therefore, that technical considerations do not prevent the production of a system using cold-cathode tubes as switching elements in the talking circuit. There is, however, the economic factor to be considered, and to throw some light on it a brief examination will be made of the trunking system of an exchange.

For various reasons it is normal practice in present-day telephony to regard 10,000 subscribers' lines as the maximum size of an exchange switching unit. This does not preclude the use in densely telephoned areas of two, three or even more such units in a single exchange building. A unit of 10,000 lines could be constructed of switching machines each large enough to give access to all 10,000 numbers. Each subscriber would be given access to one such machine on making a call and the machine would select the number dialled and connect the calling subscriber to it in only one stage of selection. Manual telephone exchanges such as have been referred to earlier can be regarded, with some reservations, as working on this principle. In automatic telephony, however, it has not yet been found practicable or economic to construct switches of 10,000 lines capacity, and exchanges are built of much smaller switches interconnected so as to select the called number by stages.

Fig. 1 shows a skeleton outline of a 10,000-line exchange built of 10,000 line selectors, and so requiring only one stage of selection to reach any line in the exchange. In Fig. 2 the same exchange is shown built of switches which have a capacity of only 100 lines or outlets each, arranged in three stages called respectively first, second and final selectors. The first selector is operated by the first digit of the dialled number, which is of four digits, to connect the calling line to a second selector in one of 10-"thousands" groups. The second selector responds to the second digit, to extend the connection to a final selector in one of 10 "hundreds" groups in that thousand. The final selector gives direct connection to 100 subscribers' lines and is operated by the last two digits of the dialled number. It has been said that each selector has a capacity of 100 outlets, yet the first and second selectors give access to only 10 thousands or hundreds groups each. The full capacity of 100 outlets is used by giving the selector access to a choice of 10 outlets to each of the 10 thousands or hundreds groups.

It should be appreciated that in Fig. 1 the number of switches provided is enough to allow as many conversations to take place as there is a demand for in the busy periods of the day and each subscriber is connected to one of the switches, when he makes a call, through a selecting mechanism which does not depend for its operation on the number dialled. In the same way there are in Fig. 2 as many switches provided as are necessary to carry the anticipated demands, hence the need for the 10 outlets to each of the thousands or hundreds groups reached from a selector. Also, as in Fig. 1, a non-numerical selecting mechanism connects the subscriber to a first selector when he calls.

Figs. 1 and 2 are only considered for the purpose of bringing out the dependence of the economics of a switching system on the trunking method adopted. The method of Fig. 1, for instance, requires fewer switches than that of Fig. 2, yet it is more costly because its switches are larger and more complex, and the number of bank contacts gives a rough measure of how much more costly it is. Thus it

* Paper read before Section G of the British Association, at Liverpool, on Friday, September 4, 1953. Abridged.

may be that for a given exchange the number of switches required for Fig. 1 may be only one quarter of the number required for Fig. 2, but each switch has 100 times as many bank contacts and thus the total number of bank contacts required for Fig. 1 is 25 times as great as for Fig. 2. Automatic systems with mechanical switches, in general, use methods similar to that of Fig. 2, although the switch used is not necessarily of 100 outlet capacity.

It will now be appreciated that the form of switching contact largely determines, by reason of its cost, the trunking method used, and this is exemplified in the methods of those systems which use crossbar switches, to which reference has already been made. The precious-metal switching contacts of these switches are more costly than the general type of wiper and bank contacts of mechanical switches and to overcome this it is necessary to revise the trunking arrangement. The principle of the co-ordinate or crossbar-type switch is shown in Fig. 3, page 413. The switch has, say, 10 horizontals and 10 verticals and at each horizontal/vertical intersection there is located a set of contacts which can be closed by first operating a magnet associated with the horizontal row and then operating a magnet associated with the vertical row. It is then usual to allow the horizontal (selecting or bar) magnet to release, leaving the set of contacts held closed under the control of the vertical (or bridge) magnet. This means that once a connection is made in a given vertical (or bridge) no other connection can be made in that bridge until the first connection is released to free the bridge magnet. As against this, however, one connection can be made in each of the 10 bridges of the switch, although there are only 100 sets of contacts totally.

Switches such as these can be used in trunking arrangements known as "link" systems in which very great reductions can be made in the number of switching contacts required. Schemes of this nature have enabled crossbar switch systems to become practicable for all sizes of exchange, in spite of the high cost of the precious-metal contacts. It is not possible here to describe such schemes in detail and it must suffice to say that a link trunking scheme is characterised by each selecting stage having two sets of switches, primary and secondary, interconnected by links. The inlets to the selecting stage are connected to the primary switches and the outlets to the secondary switches.

The switching contacts of the co-ordinate switch structure can be replaced by groups of cold-cathode tubes or other electronic switching devices, one device for each pair of "make" contacts. Controlled by suitable circuits which can choose the correct set to be operated in accordance with the selecting information given by the subscriber's dial, such electronic devices can be built up into a complete switching system. To make such a system economically practicable, it is however necessary that the cold-cathode tubes be produced as cheaply as the contacts of the crossbar switches and there is not yet any conclusive evidence that this can be done. It would appear therefore that progress in this type of electronic switching system must wait upon the production of an electronic switching contact device capable of production at a lower cost than has yet appeared.

Another line of development lies in the use of multiplex systems. A multiplex system is one in which a number of conversations can be carried on simultaneously over a single pair of wires, or over two pairs, one for each direction of speech. In mechanical switch systems each switch has a single inlet and a multiplicity of outlets, so that when the single inlet is in use no other call can occupy the same switch and all but one of its bank contact sets are wasted. As we have seen, the crossbar type of switch can, to some extent, overcome this by allowing one call simultaneously in each of its bridges, so that the number of wasted contacts is reduced. A multiplex system would appear to offer a still greater economy in switching contacts or their equivalent. Consider, for example, a multiplex switch in which 100 possible conversations may be simultaneously proceeding, and which has 100 inlets and 100 outlets. If 100 inlets are connected to 100 outlets, there are no wasted contacts and the switch could not be more efficiently used. In practice, however, selector switches have their outlets in groups, and the outlets free at the moment a given outlet requires connection may not be in the right group. Hence it would be necessary to have more outlets than inlets and some wasted contacts are inevitable.

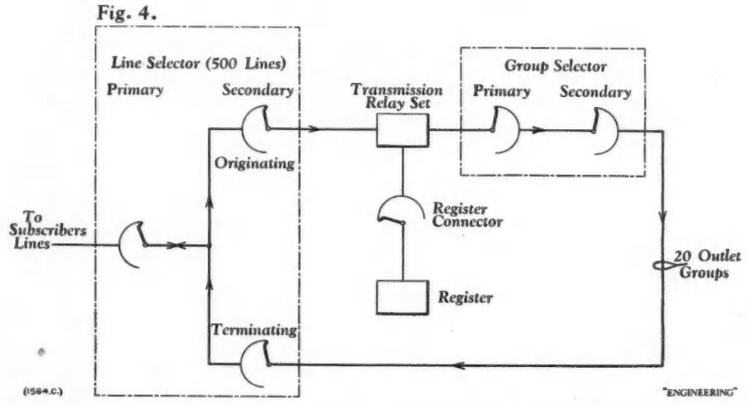
Two types of multiplex system are known as frequency-division and time-division. In a frequency division multiplex system, a switch is formed by a common carrier circuit over which a multiplicity of speech paths may be completed, each path having its own distinctive carrier frequency. In such a switch each incoming trunk may have its own fixed carrier frequency and connection may be made between it and a given outgoing trunk by using the same frequency to modulate and demodulate the speech signals on that particular outgoing trunk. A system of this nature is obviously based on multi-channel carrier-current technique as used widely in long-distance telephone transmission. In the long-distance line network, however, the emphasis must be on the greatest possible use of the trunk lines and the speech channels must therefore be confined to the minimum band width recognised as necessary for good transmission. This requires that the various components such as filters must be designed to very close limits and be therefore expensive. In using carrier switching technique inside an exchange the channel spacing may be wider, with consequent cheapening of the components. It does not appear practicable to design a large exchange with a single carrier-type switch capable of connecting to all the lines of the exchange. Hence smaller switches with a capacity of, perhaps, 100 or 200 lines each, might be used and built into a trunking system using several stages of selection.

In a time-division multiplex system, a switch is formed by a common circuit over which a multiplicity of conversations may be simultaneously carried on, each conversation having the use of the common circuit for a short time at recurrent fixed intervals. In this way, instead of the conversation being continuously transmitted from end to end of the circuit, samples of it are transmitted at definite intervals. If the rate of taking the samples is high enough, the speech is adequately received at the outgoing end of the circuit. For ordinary good quality speech, each conversation must be sampled at a rate of at least 10,000 times per second. If there are 100 paths through the switch, then the maximum time for which each could be connected would be one micro-second. Because a high scanning rate is essential the number of outlets which can be connected to any one switch is limited and therefore it is necessary to build up the complete trunking system for an exchange by using several stages of selection.

Examples of both these multiplex types have been described* but none appears to have yet got beyond the experimental stage and it is premature to say whether they will or will not afford a practicable solution. Other methods of providing electronic speech paths have been proposed, but enough has now been said to show that there are several ways in which this provision may be made and that the evidence is not yet conclusive as to their relative prospects of replacing present methods.

Electronic Control Methods.—It is now desired to devote some attention to the methods by which the selection of paths in a telephone exchange may be controlled electronically. The major functions of the controlling equipment have already been listed in an earlier section. It has been proved possible to perform them by electronic means, not only when the actual talking connections are completed through electronic devices, but also when they extend through switching mechanisms of the electromagnetic type. While it is not yet clear, in the present state of the switching art, whether any material advantages are to be had by the total replacement of the present electro-mechanical switching contacts by electronic devices it is clear that advantages may be obtained by replacing the present electromagnetic relay control of switching by electronic methods. These advantages are due to the much higher operating speeds of which electronic devices are capable. We must be clear what this higher speed actually means. In any automatic switching system, the machine cannot complete the selection of the called number before the subscriber has finished dialling. Therefore the time of setting up calls is largely determined by the speed at which the subscriber's dial switch may be operated. In the system used in London and other large towns there is even now a delay of a few seconds between completion of dialling and receipt of the ringing tone. As time goes on, it is expected that subscribers will dial more and more of their own trunk calls, which will involve more digits in the numbers dialled and will require more complex routings, in the course of which it may be necessary to transfer selecting information from exchange to exchange. The delay in completion apparent to the subscriber will greatly increase if the control is still by electromagnetic devices but the speed of electronic controls can avoid this. The dial switch fitted to present telephone instruments is very reliable, and represents a considerable capital investment; nevertheless it is not altogether improbable that a much faster subscriber's impulse sender may be designed and provided. One such has already been described.* In this event electronic control methods will be able to take full advantage of the increased speeds. Apart from the advantages apparent to the subscriber, the faster operation helps the exchange systems designer, because faster operation of control equipment means that less of it need be supplied for the operation of the same number of calls.

Fig. 4.



Electronically-Controlled Crossbar System.—To illustrate the use of electronic control methods the rest of this paper is devoted to a description of such methods applied to an experimental system using switches of the crossbar type for the completion of the actual speech paths. These methods could be applied with little change to a system using cold-cathode tubes as the conversational switching elements.

A skeleton trunking diagram of the system is

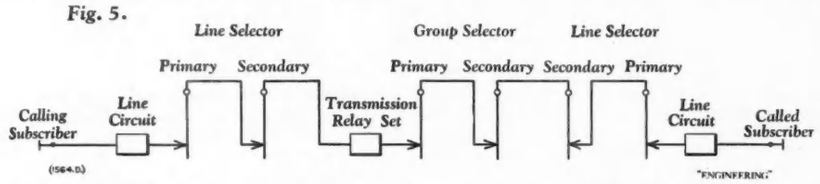
* T. H. Flowers, "Electronic Telephone Exchanges," *Proc. I.E.E.*, vol. 99, Part I, page 181.

* W. A. Malthaner and H. Earle Vaughan, "An Experimental Electronically-Controlled Automatic Switching System," *Bell System Technical Journal*, vol. 31, page 443.

shown in Fig. 4, opposite. Here for simplicity the crossbar switches of the speech paths are shown by means of the normal uniselector symbol and the same is true of the register connector, which is entirely electronic. The exchange is of 10,000 lines capacity, arranged in 20 groups of 500 lines each. There are two selecting stages, known respectively as the line selector and the group selector. Each of these is built up of primary and secondary switches with link connections. The line selector deals with both the calls originated by, and made to, the subscribers. In the primary switches of this stage, all the bridges may handle both originating and terminating calls. In the secondary switches, separate bridges handle the originating and terminating traffic, those dealing with the former being associated with the inlets of the group selector through transmission relay sets and those dealing with the latter to the outlets of the group selector. Each secondary switch bridge in the line selector has 20 outlets each leading to a different primary switch bridge. Each of the latter has access to 25 subscribers, thus allowing access to 500 subscribers' lines from each secondary bridge, whether it deals with originating or terminating traffic.

The inlets to the group selector are connected to the horizontals of the 10 primary switches, and the outlets to the bridges of the 20 secondary switches. Each primary switch has 10 inlets and 20 outlets, the latter being connected by links to inlets of the secondary switches which have also 10 inlets and 20 outlets. A group selector unit thus has 100 inlets, 200 links and 400 outlets. The 400 outlets may be divided into 20 groups of 20 outlets each, leading to the 20 different 500-line groups of the exchange. The diagram does not show provision for junctions to other exchanges, but these can be added by increasing the outlets from the secondary switches of the group selector and connecting the outgoing junctions to these. Incoming junctions from other exchanges can be connected to inlets of the group selector.

Fig. 5.



The transmission relay-set includes the conventional relay-type battery-feeding bridge supplying talking current to both subscribers; also the equipment required for signalling between the subscribers and for holding and releasing the connection. The register is connected to the calling subscriber's line through the register connector when he lifts his telephone to make a call. Its function is to receive the digits dialled by the subscriber, to store them, and to pass them at the appropriate time to the control circuits of the crossbar switches for making the connection required. It is then made free for another call. It follows that, since a register is only concerned with the actual setting up of calls, the quantity required for the whole exchange is comparatively small.

There are two main common controls (not shown in Fig. 4) associated with the two switching stages. The line selector control, of which there is one per 500-line group, connects a calling subscriber through the switches of the line selector to a free transmission relay-set. For a call terminating in its own 500-line group, the control co-operates with the group selector control to connect the calling transmission relay-set through the group selector and line selector stages to the called subscriber. The group selector control is common to the exchange. It is brought into use by the register when the latter has received all the digits of the called number and, in conjunction with the line selector control, it provides for the operation of the necessary crossbar switch magnets to complete the connection. The average approximate holding time of the line selector control is 20 milliseconds for an originating call and 15 milliseconds for a terminating call; that of the group selector control is 40 milliseconds. These times are not long enough to cover the full operation of magnets in the crossbar switches, but an auxiliary electronic switch control is provided for each switch which enables the main controls to be released as soon as they have indicated which magnets are to be operated. The individual switch control equipment also releases when the magnet operations are complete.

The line selector common control includes a cold-cathode tube scanner which continually moves over all 500 lines in the group at 4,000 steps per second. When a subscriber calls, the next scan of his line causes a marking signal to be sent to the control, stops the scanner and starts a sequence-counter circuit which controls the various stages of setting up a connection to a transmission relay-set. The marking signals from the calling line circuit mark all available free paths from that circuit through the primary and secondary crossbar switches. A high-speed (20,000 steps per second) hunting circuit starts to search in a fixed order over all outgoing trunks to transmission relay-sets, stopping at the first one which is free and also available to the calling subscriber. The necessary select and bridge magnets of the crossbar switches are then operated by the switch controls, but the main common control is released as soon as the switch controls have been notified which magnets to operate.

A register control now hunts at 20,000 steps per second to connect the transmission relay-set to a free register and dial tone is transmitted to the subscriber, who may now dial. The register receives the dialled impulses on a binary counter and transfers each digit as received to a binary store, freeing the counter for the next digit. When all digits have been received, the register signals the group selector common control to start a high-speed hunt to search for and connect itself to it. The register displays to the common control, over a set of wires common to all registers, the digits recorded in its stores. These digits are held in binary form, but the control converts them back to decimals before seizing the line selector control of the 500-line group containing the called number. The group-selector common control tests through the register to make sure that the switch control of the group selector primary switch with which the calling transmission relay set is associated is not still controlling a previous call and, if it is free, marks all available paths from the relay set through the primary and secondary switches to the group-selector outlets, including outlets to line-selector groups not actually required. The group-selector control now seizes the appropriate line selector common control, if necessary waiting until it has finished setting-up an originating call already started, stops the scanner and transfers to marking tubes in the line selector control the hundreds, tens, and units digits of the called number.

These cause the called number's line circuit to behave as if the subscriber were initiating a call, and the line selector common control marks all available paths through the primary and secondary switches, and starts a high-speed hunt, but this time for an incoming trunk from the group selector. The hunt stops at the first free trunk which has been marked by the group selector control. If the called number is free, the switch controls of the line selector and the group selectors are notified as to which select and bridge magnets are to be operated to connect the transmission relay set through the selected path to the called line. The line selector and group selector common controls are now released; also the register. When the magnet operations in the various switches are completed the switch controls are released to allow other calls to be set-up in the same switches, and the connection from subscriber to subscriber is maintained through the chain of switches shown in Fig. 5. Ringing current is sent to the called subscriber's bell from the transmission relay-set; when the subscriber answers, the ringing is tripped and the calling subscriber's meter concerned with charging the call is operated as in normal practice. The release of the connection is controlled by both subscribers' telephones; the complete connection is not freed until both have cleared.

The condition of the called number, whether it is free, busy, or not actually allocated to a subscriber, is tested from the register through the group selector and line selector common controls before the connection is set up. If the test indicates that the number is busy or unused the register signals to the transmission relay-set and the latter sends busy or number unobtainable tone to the calling subscriber. The connection is not set-up further, the register and common controls release, and the subscriber is left connected to the transmission relay set until he replaces his telephone.

(To be continued.)

NOTES ON NEW BOOKS.

Manual for the Design of Ferrous and Non-Ferrous Pressure Vessels and Tanks.

By KARL SIEMON. Fourth edition. Edwards Brothers Incorporated, Ann Arbor, Michigan, U.S.A. [Price 3·85 dols.]

THIS authoritative book will be found to be of considerable value to the rapidly increasing number of designers in this country who have to contend with the intricacies of the American pressure-vessel codes, namely, those of the American Society of Mechanical Engineers and of that Society in conjunction with the American Petroleum Institute. There are also many sections which will assist pressure-vessel designers generally. The book, consisting of nearly 300 pages, has 27 chapters and an appendix, and a number of worked examples. It is well illustrated, and there are references at the end of each chapter for those who wish to make a deeper study. Of particular interest to designers will be those sections dealing with pressure-vessel problems not covered by the official rules and regulations in this country, in which category comes the section on "Flange Design," which is very fully dealt with and will be found to be of particular value. A considerable portion of the book is devoted to the design of non-ferrous pressure vessels and tanks, including those of copper, Everdur, aluminium, Monel, nickel, stainless steel, and alloy-clad steel. There are also chapters on heat stresses in shells, shell stresses due to dead loads and wind loads, and on the supporting of vessels.

La Spectroscopie d'Émission et ses Applications.

By PIERRE MICHEL. Collection Armand Colin, No. 280. Librairie Armand Colin, 103, Boulevard Saint-Michel, Paris (5e). [Price 260 francs.]

IN this new addition to the Collection Armand Colin, Mr. Michel, director of the physical laboratory of the Renault organisation, is mainly concerned with the applications of emission, as distinct from absorption, spectroscopy, which are becoming of increasing importance in industry. A short introduction is followed by an outline of the physical basis of spectroscopy, covering such topics as atomic structure, origin of spectra and intensities of spectral lines, the effect of temperature, pressure, electric and magnetic fields on the intensity and frequency of spectral lines, and containing the minimum theoretical background needed for intelligent work in spectroscopy. The remainder of the book is devoted to spectroscopic equipment and experimental techniques, beginning with the various types of luminous source—flame, discharge tube, arc and spark—and then considering in detail the construction and adjustment of prism and grating spectroscopes and their comparative merits in respect of dispersive and resolving power, luminosity, etc. The principal means of studying a spectrum is by the location of its line images on a photographic plate and the measurement of their intensities and a thorough exposition of all that this involves is given. Following this is a briefer account of the use of photo-electric cells and a section on the design and use of micro-densitometers. The next two chapters deal, respectively, with qualitative, semi-quantitative and quantitative analysis by photographic means. In the final chapter, methods of direct analysis are considered in which photo-

electric cells and electron multipliers are used to secure practically instantaneous records, and two of the elaborate instruments constructed for this purpose are described and illustrated. A remarkable amount of information based on first-hand experience is contained in this little manual.

Symposium on Continuous Analysis of Industrial Water and Industrial Waste Water.

The American Society for Testing Materials, 1916, Race-street, Philadelphia 3, Pa. [Price 1·50 dol.]

THIS symposium, published in June, 1953, comprises five papers presented at the Fifty-fifth Annual Meeting of the American Society for Testing Materials, held in New York during June, 1952, dealing with "Automatic Sampling of Industrial Water and Industrial Waste Water," by M. F. Madarasz of the Ford Motor Company, Dearborn, Mich.; "Some Practical Aspects of the Measurement of *p*H, Electrical Conductivity, and Oxidation-Reduction Potential of Industrial Water," by Robert Rosenthal of Industrial Instruments, Inc. Cedar Grove, N.J.; "Continuous Recording of Chlorine Residuals and Determination of Chlorine Demand," by A. E. Griffin of the Wallace and Tiernan Company, Inc., Newark, N.J.; "Measurements of Color, Turbidity, Hardness, and Silica in Industrial Waters," by F. C. Staats of the Hercules Powder Company, Wilmington, Del.; and the "Continuous Measurement of Dissolved Gases in Water," by J. K. Rummel, senior engineer to Sheppard T. Powell, consulting engineer, Baltimore, Md. The background to these papers, which in themselves are informative and illustrate new types of equipment, is that "Industry, having recognised water as an essential engineering material, is frequently called upon to evaluate its properties, both from the standpoint of its use and its disposal." The various papers stress the importance of continuous and automatic sampling, which can lead to the setting up of automatic control of processes and a consequent saving in labour. This publication, with its 54 pages and many references to current literature on the subject, serves as an excellent introduction to this particular branch of engineering.

TRADE PUBLICATIONS.

Industrial Diesel Engines.—A copy of a brochure has been received from Leyland Motors, Ltd., Leyland, Lancashire, describing their range of industrial Diesel engines. Of the four-stroke direct-injection type, they have outputs ranging from 91 to 150 b.h.p. on a one-hour rating, or from 64 to 115 b.h.p. on continuous rating.

Packing and Packaging.—Efficiency in packing can be enhanced by the use of special tapes and labels, dispensed from machines. A wide range is described in a pamphlet issued by Samuel Jones & Co., Ltd., New Bridge-street, London, E.C.4.

Leaf-Spring Design.—Mr. Alan Hodgson, deputy general manager of Richard Berry & Son, Birmingham-road, West Bromwich, Staffordshire, has written a booklet giving design data and formulæ for leaf springs. In his preface, the author states "The storing of energy is the prime function of a road spring, and any feature which tends to destroy this capacity should be examined critically before being accepted as part of the design." The booklet should be of use to the motor industry, and senior executives can obtain free copies from J. Brockhouse & Co., Ltd., 25, Hanover-square, London, W.1, the proprietors of Richard Berry & Son.

Tube Expanders.—A comprehensive range of tube expanders is described in a series of leaflets published by Ormonde Ashton, Ltd., Union Works, Ormonde-street, Ashton-under-Lyne, Lancashire. Models are obtainable for tubes ranging in diameter from ½ in. to 5 in., and for either taper or parallel expansion.

Mosaic Diagrams for Control Boards.—Details of the design and equipment of their mosaic diagrams for control boards are given in a leaflet received from the Automatic Telephone and Electric Co., Ltd., Strowger Works, Liverpool, 7.

Protection of Hands.—Innoxa Laboratories, 170, New Bond-street, London, W.1, have sent us samples of Innoxa 51 and Innoxa 71, preparations for protecting the hands of persons engaged on dry or wet work, respectively, which is likely to damage the skin.

Guillotines for Slate and Asbestos.—Portable guillotines, weighing less than 20 lb., for cutting slate or asbestos sheet are described in a leaflet issued by H. Freeman, 10, Fairbourne-road, London, N.17. When cutting asbestos, the sheet is laid on boards and located by the guide angles supplied, and the guillotine slides forward after each cut is made. It is claimed that an 8-ft. cut can be made in ten seconds and, as there is no sawing action, the process is dust-free. Hardboard or thin sheet-metal can be cut equally well. The guillotine for slate-cutting is smaller and the slate has to be moved forward after each stroke. It is primarily intended for cutting small pieces such as are required in roofing.

Industrial Power Plant.—We have received two illustrated pamphlets from Richardsons, Westgarth & Co., Ltd., Wallsend-on-Tyne, giving details of some of the turbines, alternators, condensing plant, boilers, turbo-blowers and marine engines that have recently been produced in their own works and in those of their subsidiary companies.

Street Lighting.—The General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2, have sent us a well-illustrated booklet showing the part they have played in the design and manufacture of street-lighting equipment since the beginning of the century. Mercury, sodium, fluorescent and tungsten lamps are all covered in an informative manner.

Direct-Current Bias Control System.—A booklet issued by Standard Telephones and Cables, Ltd., Aldwych, London, W.C.2, gives details of their direct-current bias system for the control of street lighting and other electrical systems.

BOOKS RECEIVED.

A Survey of Some Mixing Plants for Asphalt and Coated Macadam. By D. B. WATERS. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* net.]

D.C. Generators and Motors. By J. E. MACFARLANE. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, London, W.C.2. [Price 8*s.* 6*d.* net.]

An Introduction to Chemical Engineering. By T. K. ROSS. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2. [Price 21*s.* net.]

Applied Thermodynamics. By PROFESSOR A. C. WALSHAW. Second edition. Blackie and Son, Limited, 17, Stanhope-street, Glasgow, C.4. [Price 40*s.* net.]

Boiler House Practice. By J. N. WILLIAMS. George Allen and Unwin, Limited, Ruskin House, 40, Museum-street, London, W.C.1. [Price 60*s.* net.]

Periodicals and Serials. Their Treatment in Special Libraries. By DAVID GRENFELL. Aslib, 4, Palace Gate, London, W.8. [Price 10*s.* 6*d.* to members of Aslib, 12*s.* 6*d.* to others.]

Index to Theses Accepted for Higher Degrees in the Universities of Great Britain and Ireland. Vol. I. 1950-51. Edited by P. D. RECORD. Aslib, 4, Palace Gate, London, W.8. [Price 25*s.* 6*d.*, post free.]

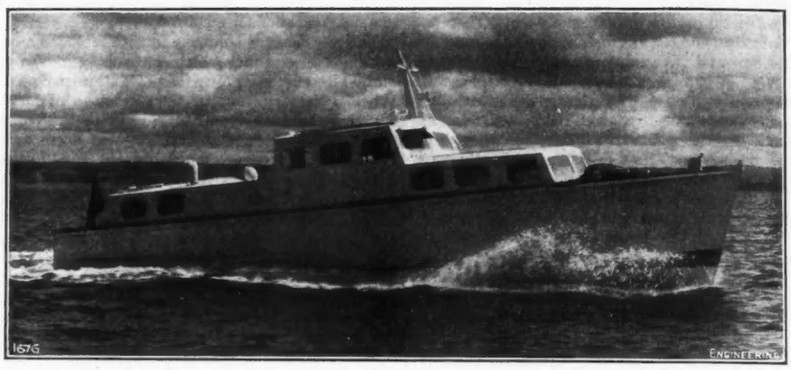
Berechnungsgrundlagen für Bauten. Edited by DR.-ING. BERNHARD WEDLER. Wilhelm Ernst und Sohn, Hohenzollerndemm 169, Berlin-Wilmersdorf, Germany. [Price 7.50 D.M. in paper covers, 10.50 D.M. bound]; and Lange, Maxwell and Springer, Limited, 242, Marylebone-road, London, N.W.1. [Price 13*s.* 2*d.* in paper covers, 18*s.* 2*d.* bound.]

Stauanlagen und Wasserkraftwerke. Part 1. *Talsperren.* By PROFESSOR HEINRICH PRESS. Wilhelm Ernst und Sohn, Hohenzollerndamm, 169, Berlin-Wilmersdorf, Germany. [Price 26 D.M. in paper covers, 30 D.M. bound]; and Lange, Maxwell and Springer, Limited, 242, Marylebone-road, London, N.W.1. [Price 45*s.* 6*d.* in paper covers, 52*s.* 6*d.* bound.]

Overseas Economic Surveys. Belgium and Luxembourg, with an Annex on Benelux. By A. H. TANDY. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3*s.* 6*d.* net.]

ALUMINIUM-ALLOY LAUNCH FOR PAKISTAN.

GRIMSTON ASTOR, LTD., NORTH BIDEFORD, DEVON.



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THE twin-screw launch illustrated on this page has been built by Grimston Astor, Limited, of North Bideford, Devon, on their "two-way tension" principle, which was described in ENGINEERING, vol. 171, page 188 (1951), and has been acquired by the British India Steam Navigation Company for use as an inspection launch on the Pussar River, in Pakistan. The vessel measures 40 ft. in length overall and 39 ft. on the waterline, with a breadth of 12 ft. and a draught in service condition of 2 ft. 9 in. The displacement is 4½ tons, and on trial, with the two Perkins S6M marine Diesel engines running at 2,000 r.p.m., the mean speed was 20·79 knots.

The hull is constructed with six compartments. The forepeak forms a store and chain-locker, aft of which is another store, fitted with a Kepcold ice-box. This compartment communicates with the saloon, which has a settee on each side (with lockers underneath) providing seats for 12 passengers. Abaft the saloon, but at a higher level, is the cockpit with the steering position on the starboard side and lavatory accommodation to port. At the after end of the cockpit there is a bench seat on each side. The next compartment is the engine room, and abaft this is the crew's compartment, communicating with it.

Each of the two Perkins engines is rated at 100 brake horse-power at 2,000 r.p.m. and has an oil-operated reversing gearbox. The propeller shafts are of stainless steel and are connected to the engines by Silentbloc flexible couplings. The propellers are of light alloy and have three blades. The engine throttle controls and the gear levers are operated by the coxswain from the steering position. The instruments comprise, for each engine, a revolution indicator, water-temperature thermometer, oil-pressure gauges for the engine and the gearbox, and an ammeter. Two 24-volt batteries, of 130 ampere-hours capacity, provide power for starting the engines and current for lighting, including the navigation lights and a 9-in. 150-watt searchlight; oil navigation lights are also fitted. Steering is effected through 1-in. wire rope, directly connected to the twin rudders, and the engine controls are of the Teleflex type. A Sestral liquid compass is fitted forward of the instrument panel. Fresh water is carried in two tanks, each of 10 gallons capacity. The equipment includes a lever-type yacht windlass and two Danforth anchors, of 43 lb. and 30 lb. weight, respectively, with 30 fathoms of $\frac{5}{16}$-in. chain cable.

CABLE-SEALING SLEEVES.—British Insulated Callender's Cables, Ltd., Norfolk-street, London, W.C.2 have developed a range of polychloroprene sealing sleeves for terminating cables used in normally dry conditions where sealing by the more orthodox method is considered unnecessary. The sleeves at present available are intended for use on medium voltage two- and three-core, cambric-insulated cables and are particularly suitable for ship wiring. The range is, however to be extended to mass-impregnated non-draining power cables for industrial installations.